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NWL Report No. 1832

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# INVESTIGATION OF STOWAGE HAZARDS IN AIR LAUNCHED MISSILE MAGAZINES: THE COMPATIBILITY OF PREPACKAGED LIQUID- AND SOLID- PROPELLANT BULLPUP MISSILES IN A COMMON SHIPBOARD MAGAZINE (U)

by

R. H. Quillin
and
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Weapons Development and Evaluation Laboratory

## U. S. NAVAL WEAPONS LABORATORY
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# Investigation of Stowage Hazards in Air Launched Missile Magazines: The Compatibility of Prepackaged Liquid- and Solid-Propellant BULLPUP Missiles in a Common Shipboard Magazine (U)

by

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BUSHIPS Allotment No. 107 BPN-70 of 22 June 1961
and
BUWEPS Task Assignment RM3754-001/210-1/W024-00-004
of 10 April 1962

16 November 1962



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## CONTENTS

## ABSTRACT

This report presents the results of an investigation to determine if the chain ignition hazards associated with the stowage of BULLPUP ASM-N-7a prepackaged liquid-propellant engines and BULLPUP ASM-N-7 solid-propellant motors in a common magazine exceeds to a significant degree, the chain ignition hazards involved in the stowage of either unit separately.

From the results of this investigation it is concluded that chain ignition is no more likely to occur in the stowage of liquid-propellant BULLPUP ASM-N-7a and solid-propellant BULLPUP ASM-N-7 units in a common magazine, to the extent of placing units on the same stanchions at random, than with comparable segregated stowage of liquid- or solid-propellant units. Critical safety measures which must be taken are to insure that the initiator opening of the liquid-propellant engine be closed at all times, either by means of the initiator or the shipping plug and that adequate restraint be provided for propulsive liquid-propellant engines.

## FOREWORD

This is a partial report on a program conducted jointly under BUWEPS Task Assignment RM3754-001/210-1/W024-00-004 of 10 April 1962 and BUSHIPS Allotment No. 107 BPN-70 of 22 June 1962.

This report was reviewed by the following persons of the Weapons Development and Evaluation Laboratory:

S. H. McELROY, Head, Engineering Branch
D. C. SLOAN, Armament Division Engineer
D. W. STONER, Director

APPROVED FOR RELEASE:

/s/ R. H. LYDDANE
Technical Director

## INTRODUCTION

The Naval Weapons Laboratory was requested jointly by the Bureau of Naval Weapons (Section RSWI), and the Bureau of Ships (Code 603) to conduct an investigation to determine whether or not BULLPUP ASM-N-7a prepackaged liquid-propellant engines and BULLPUP ASM-N-7 solid-propellant motors are compatible for stowage in a common magazine. It is planned that BULLPUP liquid-propellant engines and solid-propellant motors will both be in fleet use during an extended conversion period commencing in mid-summer of 1962. Safety regulations existing prior to this conversion would prohibit integrated stowage of the unlike units; however, for logistic reasons it is felt that it may become necessary (or at least desirable) that both kinds be stowed together in the same magazine.

"Compatibility", as used herein, implies that the chain ignition hazards associated with stowage of the two dissimilar kinds of units in the same magazine will not exceed, to any significant degree, the chain ignition hazards involved in the stowage of either unit separately.

In considering the conflagration of propellant components within a missile magazine, two separate conflagration phases are conceivable; the ignition of one or more propellant components initially, and the subsequent ignition (or chain ignition) of other propellant components not involved initially but which results from the primary ignition. The various possible means of obtaining initial accidental ignitions were not investigated; it was simply assumed that accidental initial ignitions are possible in the day-to-day activity in and around magazine areas and weapon check-out spaces and by such ever-present possibilities as the collision of ships and shipboard fires. It should be noted that numerous efforts are being made, or have been made to reduce the likelihood of primary ignitions. These include the reduction of the susceptibility of initiation by electromagnetic radiation or static electricity, the establishment of handling and checkout safety procedures, the selective location of the magazine and careful attention to structural aspects of its design.

As mentioned, chain ignitions are those that occur subsequent to initial accidental ignitions. They may occur as a result of an increase in the general magazine temperature or by the impingement of high velocity, high temperature gases on an adjacent unit, either directly from unit-to-unit or by reflection from a bulkhead or other structure.

Extensive efforts have been conducted at the Naval Weapons Laboratory during the past six years to devise measures which will prevent the occurrance of chain ignition of solid-propellant motors and liquid-propellant engines stowed separately in magazines. Numerous systems have been developed to prevent the chain ignitions, whether the "donor" motors are expected to burn propulsively or nonpropulsively. These systems include magazine sprinkling, water injection, magazine venting, plenum chamber and ducts, shielding, and protective closures and containers. In addition to these measures, consideration is normally given to the geometrical arrangement of the stowed units within a magazine and to the segregation of unlike propellants.

In planning the compatibility investigation, it was assumed that at least the following minimum safety systems and equipment would apply to integrated stowage:

a. Magazines used for mixed stowage would meet all requirements for protective devices and damage control equipment currently applicable to solid-propellant rocket motor magazines and in addition would meet all such requirements currently applicable to magazines in which liquid-propellant rocket engines are stowed.

b. Only production motors and engines of designs which have satisfactorily passed qualification tests pertaining to safety features would be subjected to mixed stowage. (Note: A publication, "Minimum Safety Criteria for Liquid-propellant Engines" is now under preparation by NWL, Dahlgren. These criteria should be fully met to minimize the hazard of liquid-propellant engines in magazine stowage.)

c. Solid-propellant rocket motors would be equipped with thrust neutralizers (nonpropulsive attachments) while in mixed stowage.

d. Initiators would not be installed in liquid-propellant rocket engines prior to stowage in a magazine, and the initiator opening would be plugged.

e. Liquid-propellant rocket engines would be provided with leak-indicating coatings, or equivalent means of detecting leakers at an early stage.

It was decided that insofar as possible, standards for deciding whether integration is permissible would be established prior to the investigation; so that data from the investigation could be evaluated directly with respect to such standards. Appropriate standards were outlined in general in reference (a) and in more detail in reference (b).

These references also prescribed that the stowage of liquid- and solid-propellants in a common magazine would be considered in at least two stages as follows:

a. Unlike propulsion units would be separated as far as possible (placed at opposite ends of a magazine) with a flame shield (portable bulkhead) provided between unlike units.

b. If integrated stowage proved acceptable to the extent defined in a. above, then complete integration (mixed loading on the same stanchions) would be considered.

## DESCRIPTION OF TEST MATERIAL

### Motors

The BULLPUP ASM-N-7 rocket motor Mk 8 Mod 1 has a cast double base solid-propellant and delivers 8,500 pounds of thrust over a burning time of 2.5 seconds at 77°F. This motor has a one-half inch aluminum shroud to which the wings are attached and a thin steel shroud that covers the nozzle and houses the tracking flares. The motor including the nozzle is 40.47" long, 12" in diameter and weighs 200.3 pounds.

The motor is stowed in the deep stowage magazine assembled with an igniter and a nonpropulsive attachment (NPA), a device that attaches to the motor case and neutralizes the motor thrust by discharging the gases radially in a 360° peripheral plane. The NPA is attached to the nozzle when the motor is shipped, handled, or stowed with the igniter installed.

### Engines

The BULLPUP ASM-N-7a prepackaged liquid-propellant rocket engine XLR58-RM-2 delivers 12,000 pounds of thrust over a burning time of 2.04 seconds at 60°F. The liquid-propellants are the oxidizer, inhibited red fuming nitric acid (IRFNA), and a mixed amine fuel (MAF-1), which are hypergolic (self-igniting upon mixing). It is necessary, therefore to keep the propellants separated until combustion is desired. A solid-propellant pressurizing grain when ignited, provides the pressure required to deliver the fuel and oxidizer to the thrust chamber. This engine is an integral unit of aluminum alloy construction with no separate engine shroud; however, there is a separate aluminum shroud for the nozzle. The engine including the nozzle is 40.47" long, 12" in diameter and weighs 200.7 pounds.

The engine is stowed without a nonpropulsive attachment and with a dummy initiator of the side insertable type, which is not replaced with a live initiator until the launch aircraft is ready for takeoff.

### Warhead

To provide information on the all-up stowage configuration which is planned for the future, an empty warhead case was instrumented with five thermocouples and then filled with wax and included in the test arrangement in most of the tests. The warhead case used was an EX 29 Mod 3 from a BULLPUP ASM-N-7a, and in these tests it was held in the center section of the missile by means of bomb chocks. The center section is 44.97" long and 12" in diameter and the warhead case was held in the center section in the same position as a warhead would be in all-up stowage.

## DESCRIPTION OF TEST EQUIPMENT

### Magazine

The simulated magazine used in the investigation was the NWL cylindrical chamber which is 22.0 feet in diameter at the base, 21.0 feet in diameter at the top, 8.5 feet in height, and has a volume of 2770 cubic feet. The sides are of 6.75 inch armor plate and the base and the top are of 4 inch armor plate. Appendix A, Figure 1 is an exterior view of this simulated magazine.

### Sprinkling System

In accordance with the approach outlined in reference (b) an operative sprinkling system was not used in this investigation; however, temperature data were analyzed with respect to the effect an operative sprinkling system would have had, allowing a 15 second actuation time from first rise of magazine temperature to full flow.

## Venting System

A magazine venting area of 12 square feet (3' x 4') was provided. This area was covered by a steel plate which had a second vent of 4 square feet (2' x 2') in the center of it, which was in turn covered by a steel plate. Both plates were held in place by bolts designed to rupture and release the vent cover plates at magazine pressures of 20 to 30 psi.

## Modular Stowage System

A portion of a modular dunnage system was installed in the magazine, the equipment and arrangement being similar to BUSHIPS Plan No. 702-1902700, Rev. D and including four deck tracks, four overhead tracks, four aluminum stanchions and eight bracket and strap assemblies. A 3/16" thick steel bulkhead, to serve as a flame shield, was provided in all tests and was installed 14" aft of the nozzles of the stowed units. In the tests of the solid-propellant motor, the nonpropulsive attachment (NPA) extended into this 14" clearance. Because the BULLPUP liquid-propellant engine is stowed propulsively, additional restraining devices were provided.

## Instrumentation

Instrumentation was provided to record temperatures and pressures in the magazine. Temperatures were also measured in the solid-propellant motor, the liquid-propellant engine, and the warhead at the places designated in Figure 2 and Table 1 of Appendix B. Motion pictures and still photographs were taken before, during and after each test. Thrust measurements were made in one test.

## Spill Arrangement

The spill arrangement used in some of the tests to induce hypergolic fires consisted of two platforms on which aluminum cans, 11 inches in diameter and 33 inches tall were attached, with one can containing 28.6 lbs of MAF-1, the other 83.5 lbs of IRFNA. The platforms were hinged at one side so they would swing down and spill the liquids on the deck. A 2" orifice was cut in the lid of each can in order to obtain the desired spill rate, and a section of aluminum pipe was welded into each orifice and fitted with a cap that was removed just prior to commencing the tests. Wire cables coupled to an explosive bolt or solenoid release mechanism were connected to each platform to keep it level prior to release. Initiation of an electric current separated the bolt or tripped the solenoid, permitting the platform to swing down and dump the contents of the cans together.

This same set-up was also used during three tests to simulate a leaking liquid-propellant engine; in these tests, instead of being spilled together, the liquids were spilled into separate containers which had holes in the underside of proper size to obtain the desired leakage rate.

## PROCEDURE, RESULTS AND DISCUSSION

The procedure followed in the investigation is presented in detail in reference (b). Test conditions and results are given below, the test designations being the same as those of reference (b).

### Series A Tests

In these tests it was desired to determine primarily whether motors and engines are compatible for stowage in the same magazine when segregated into like groups and separated by a flame shield.

### Tests A-1-a, b, c

These initial tests were designed to accomplish the following:

a. To determine whether a liquid-propellant engine will ignite if subjected to the environment of a representative liquid-propellant casualty condition.

b. If ignition occurs, to determine:

(1) the nature of burning,

(2) the effects of burning on another liquid-propellant engine and,

(3) the effect on a solid-propellant motor and a missile warhead.

Test A-1-a (Conducted 27 April 1962)

Two liquid-propellant engines, one solid-propellant motor, one wax filled simulated warhead and one flame shield were arranged as indicated in Appendix C, Figures 3 and 4. In this and subsequent tests, the propellants were spilled during 15 seconds into a tray under a liquid-propellant engine (this engine is considered to be the active unit), with the distance from the deck to the underside of the active unit being 20", the same as from the deck to the second level of the modular stowage system. In this test, the engine was stowed in the same manner as normally aboard ship; i.e., propulsive with dummy initiator installed. The active unit was set in a special stand so that thrust could be measured by a load cell if ignition occurred.

Results

Fuel and oxidizer ignited on contact and burned. The active engine did not ignite, but the nozzle shroud was partially eroded and the paint on the engine was discolored. The passive units were slightly discolored by flame and heat but did not approach ignition or cook-off temperature. Magazine pressure was not sufficient to dislodge the vent cover, but heat damaged the nylon tie-down straps, and charred the plastisol coating on the motor holding brackets. Damage to the aluminum stanchions was negligible. The results of this test are presented in Appendix D, Figure 15 and Table 2.

Test A-1-b (Conducted 1 May 1962)

The set-up for this test was identical to test A-1-a except that the dummy initiator was removed. This change was originally not included in reference (b) but was suggested following test A-1-a because it was reasoned that this condition would be possible following the return of an engine to the magazine from ready service. To increase the severity of this test the initiator opening was not plugged and was faced downward toward the burning propellants. The set-up is pictured in Appendix C, Figures 5 and 6.

Results

The spillage fire burned for 2.69 seconds before the active engine over the spillage area ignited and burned semi-propulsively, venting from both the nozzle and initiator openings for 2.3 seconds and developing a maximum thrust of 4100 lbs as compared to a normal thrust of 12,000 lbs.

Motion pictures of the magazine showed sufficient displacement of the overhead to allow the modular stowage stanchions to be lifted out of the deck tracks and to permit the blast from the burning engine to cause the passive units to be blown, with the stanchions and the bulkhead, away from the active unit. These units were only slightly damaged and did not ignite. The results of this test are presented in Appendix D, Figures 16, 17 and 18 and Table 2.

Test A-1-c (Conducted 11 May 1962)

This test was conducted with an empty engine containing a live initiator as the active unit because it was reasoned that it would be possible for a live initiator to be left in an engine on return of an engine to the magazine from ready service. This engine was placed so that it would be over the fire resulting from a spillage of propellants (15 seconds spill duration) as in tests A-1-a and A-1-b. No passive units were included in this test. The set-up is pictured in Appendix C, Figure 7.

Results

The live initiator in the inert active engine did not cook-off. The results of this test are presented in Appendix D, Figure 19 and Table 2.

Discussion

Results of the A-1 series of tests indicated that the following can be expected with integrated stowage:

a. An engine stowed with the initiator opening plugged, either by the shipping plug or the initiator, probably will not ignite if subjected to a hypergolic fire resulting from the spillage of the propellants from another engine.

b. An engine that has been returned to the magazine and stowed with the initiator opening unplugged, probably will ignite if it is within a hypergolic fire, but if ignited in this way, it will not burn in a fully propulsive manner since it will exhaust from the initiator opening as well as the nozzle.

c. An ignited engine will not cause chain ignition of other liquid- and solid-propellant units if direct flame impingement is prevented by a suitable flame shield.

d. The employment of a sprinkler system in the magazine would not have influenced the results of the tests of this series. For example, in tests A-1-a, and A-1-c chain ignition did not occur even in the absence of a sprinkling system. In test A-1-b chain ignition occurred in a time interval shorter than the normal time for water to begin flowing from a sprinkling system.

Tests A-2-a, b

These tests were designed to:

a. determine whether a solid-propellant motor will ignite if subjected to the environment of a representative casualty of a liquid-propellant engine,

b. determine the nature of burning if such ignition of the motor occurs and,

c. determine the effects of this burning (should ignition occur) on a liquid-propellant engine, a second solid-propellant motor and a missile warhead, all separated from the first motor by a flame shield.

Test A-2-a (Conducted 15 May 1962)

Two solid-propellant motors, one liquid-propellant engine, and one wax filled simulated warhead were arranged as indicated in Appendix C, Figure 8. A heat environment was created by the simultaneous spillage (15 seconds spillage duration) of fuel and oxidizer into a tray under an active solid-propellant motor. The make-up of this motor was the same as it would have been aboard ship, i.e., it included a live igniter and a nonpropulsive attachment.

Results

The active motor did not ignite and other than the paint being slightly charred, was not damaged. The passive units did not ignite and neither the active unit nor the passive units approached cook-off temperature. Magazine pressure was not sufficient to dislodge the vent cover. The results of this test are presented in Appendix D, Figure 20 and Table 2.

Test A-2-b (Conducted 16 May 1962)

The set-up for this test was identical to test A-2-a; but in this test the active unit was electrically ignited so that the effects of a burning solid-propellant motor on the passive units could be compared with the effects of a burning liquid-propellant engine on comparable passive units as determined in test A-1-b. The active unit was ignited 3.6 seconds after the start of spillage of fuel and oxidizer (this was done to maintain the same time interval between spillage and ignition of a liquid-propellant engine as in test A-1-b). The set-up is shown in Appendix C, Figure 9.

Results

The passive units did not approach cook-off temperature and were not damaged other than blistering of the paint on the nozzle shroud of the liquid-propellant engine and some discoloring of the paint on all the units. The results of this test are presented in Appendix D, Figures 21 and 22 and Table 2.

Discussion

Results of the A-2 series tests indicated that the following can be expected with integrated stowage:

a. A solid-propellant motor is not likely to ignite if subjected to a hypergolic fire resulting from the spillage of propellant from a liquid-propellant engine.

b. If the solid-propellant motor should ignite, passive units protected by a steel flame shield are not likely to be ignited.

c. The use of a magazine sprinkling system would give further assurance of preventing ignition of the passive units. The recorded maximum temperatures of the passive units, in both tests, occurred considerably after 15 seconds from the origin of the spillage, and with a normal sprinkling system, which operates within 15 seconds, the maximum temperatures would have been considerably lower.

Series B Tests

The tests in Series A were reviewed at a conference called by BUWEPS on 21 May 1962 during which it was decided that there was sufficient evidence to recommend that unlike units be stowed in the same magazine provided flame shields were placed between unlike units. It was agreed to continue the investigation by commencing another series of tests, designed to determine whether solid-propellant motors and liquid-propellant engines could be stowed together on the same stanchions, and to modify the first two tests of Series B of reference (b) as described below:

Test B-1-a (Mod) (Conducted 29 May 1962)

To observe the effects of a burning liquid-propellant engine on another liquid-propellant engine and a solid-propellant motor under the closest stowage conditions, i.e., on the same stanchions, passive units would be subjected to the exhaust gases of an active unit reflected from a flame shield.

Two liquid-propellant engines and one solid-propellant motor containing a partial grain (4" segment in the after end) were arranged as indicated in Appendix C, Figure 10. The active engine was electrically ignited and burned normally.

Results

The paint on the passive units was generally discolored and burned off at the nozzle ends, and the nylon tie-down straps were burned through; however, the passive units did not ignite, were not otherwise damaged, and did not approach cook-off temperature. The 3/16" steel flame shield, 14" to the rear of the unit, was warped by the blast from the active liquid-propellant engine but was not burned through. The results of this test are presented in Appendix D, Figures 23 and 24 and Table 2.

It should be noted that under service conditions the stanchions and tie-down straps would not have restrained the propulsively burning liquid-propellant engine. This was anticipated prior to the test and the additional restraining structure shown in Figure 10 was provided for this purpose.

Either adequate restraining structures or some means of reducing the thrust level are necessary for service stowage of liquid-propellant engines.

Test B-2-a (Mod) (Conducted 5 June 1962)

To determine what effects a burning solid-propellant motor would have on another solid-propellant motor and a liquid-propellant engine, at the closest stowage conditions, i.e., on the same stanchions, passive units were subjected to the exhaust gases discharged from the nonpropulsive attachment (NPA) of the active unit.

Two solid-propellant motors and one liquid-propellant engine were arranged as indicated in Appendix C, Figure 11. The passive solid-propellant motor in this test contained only a partial grain (4" grain segment in the after end).

Results

The nozzle shroud of the passive liquid-propellant engine was burned completely off, the nozzle shroud of the lower solid-propellant passive unit was burned almost entirely off, and the nonpropulsive attachment (NPA) closure band was dislodged; however, the two passive units did not approach ignition or cook-off temperature. Only one nylon tie-down strap was used in this test and it burned through. The results of this test are presented in Appendix D, Figures 25, 26 and 27, and Table 2.

Discussion

Results of the series B-1 and B-2 tests indicated that the following can be expected with integrated stowage:

a. If either a liquid or a solid propellant unit in a tier of units that are attached to modular stowage stanchions becomes ignited, it probably will not cause chain ignition of other liquid- or solid-propellant units on the same stanchions.

b. The employment of a typical magazine sprinkling system should not influence the probability of chain ignition, since in these tests, chain ignitions were not experienced and heating of propellants in passive units was not serious, even without the protection afforded by such a system.

Tests B-3-a, b

These tests were designed to determine:

a. the effect of the simultaneous leakage of propellants at various leakage rates directly on a solid-propellant motor and,

b. the effect of the environment created by such leakage on a passive liquid-propellant engine and a wax filled simulated warhead.

Test B-3-a (Conducted on 12 June 1962)

A solid-propellant motor, a liquid-propellant engine, a wax filled simulated warhead and an arrangement designed to simulate a leaking liquid-propellant engine, at a rate of one normal quantity of the propellants in 15 minutes, were arranged as indicated in Appendix C, Figure 12. The test was initiated by allowing the propellants to leak directly onto the solid-propellant motor.

Results

Neither of the passive units ignited, and although the solid-propellant motor, positioned directly under the leaking dummy engine, developed outer case surface temperatures in the order of 1600°F, only a small rise in grain temperature occurred. Likewise, the liquid-propellant engine developed high temperatures on the surface of the case but only a small temperature rise occurred in the propellants. The warhead was damaged on its underside by the fire, but the temperature rise of the wax filler was only 50 to 60°F. All maximum temperatures recorded, with the exception of external case temperatures, were reached after approximately 10 to 25 minutes. The results of this test are presented in Appendix D, Figure 28 and Table 2.

Test B-3-b (Conducted 13 June 1962)

The set-up and procedure in this test were identical to test B-3-a except that the leakage rate was increased to one normal quantity of the propellants in one minute. The set-up is pictured in Appendix C, Figure 13.

Results

The exterior or case temperatures of the passive units were similar to those recorded in test A-3-a; however, the interior temperatures were less than those recorded in that test, with maximum interior temperatures being reached after approximately six minutes. The results of this test are presented in Appendix D, Figure 29 and Table 2.

Test B-3-b-1 (Conducted 29 June 1962)

Sufficient time and hardware remained after the test B-3-b to conduct another test, and it was decided to repeat test B-3-b with dummy passive units, which permitted instrumenting to a greater extent than possible with live units. Water was substituted for the fuel and oxidizer in the tanks of the liquid-propellant engine, and thermocouples were positioned in each tank. Thermocouples were positioned also at both ends of a dummy grain in the solid-propellant motor. The set-up is pictured in Appendix C, Figure 14.

Results

The temperatures recorded on the case of the passive unit were less than those recorded in tests B-3-a and B-3-b because the Pyrolock insulation on the thermocouple junctions was not burned away to the extent experienced in the previous two tests. The interior temperatures were not as high in this test as they were in test B-3-a, although they were higher than the temperatures recorded in test B-3-b.

The results of this test are presented in Appendix D, Figure 30 and Table 2.

Discussion

Results of the B-3 series of tests indicated that the following can be expected with integrated stowage:

a. A liquid-propellant engine leaking both fuel and oxidizer simultaneously at the rate of one normal quantity in 15 minutes or less, probably will not create an environment of sufficient severity to cause chain ignition of other propellant or explosive units within the environment.

b. The action of a magazine sprinkling system would have a significant effect in increasing the probability that no chain ignition or cook-off would occur since at 15 seconds (approximately) after burning commenced, magazine temperatures would be reduced significantly by the effect of water flow and the burning would probably cease.

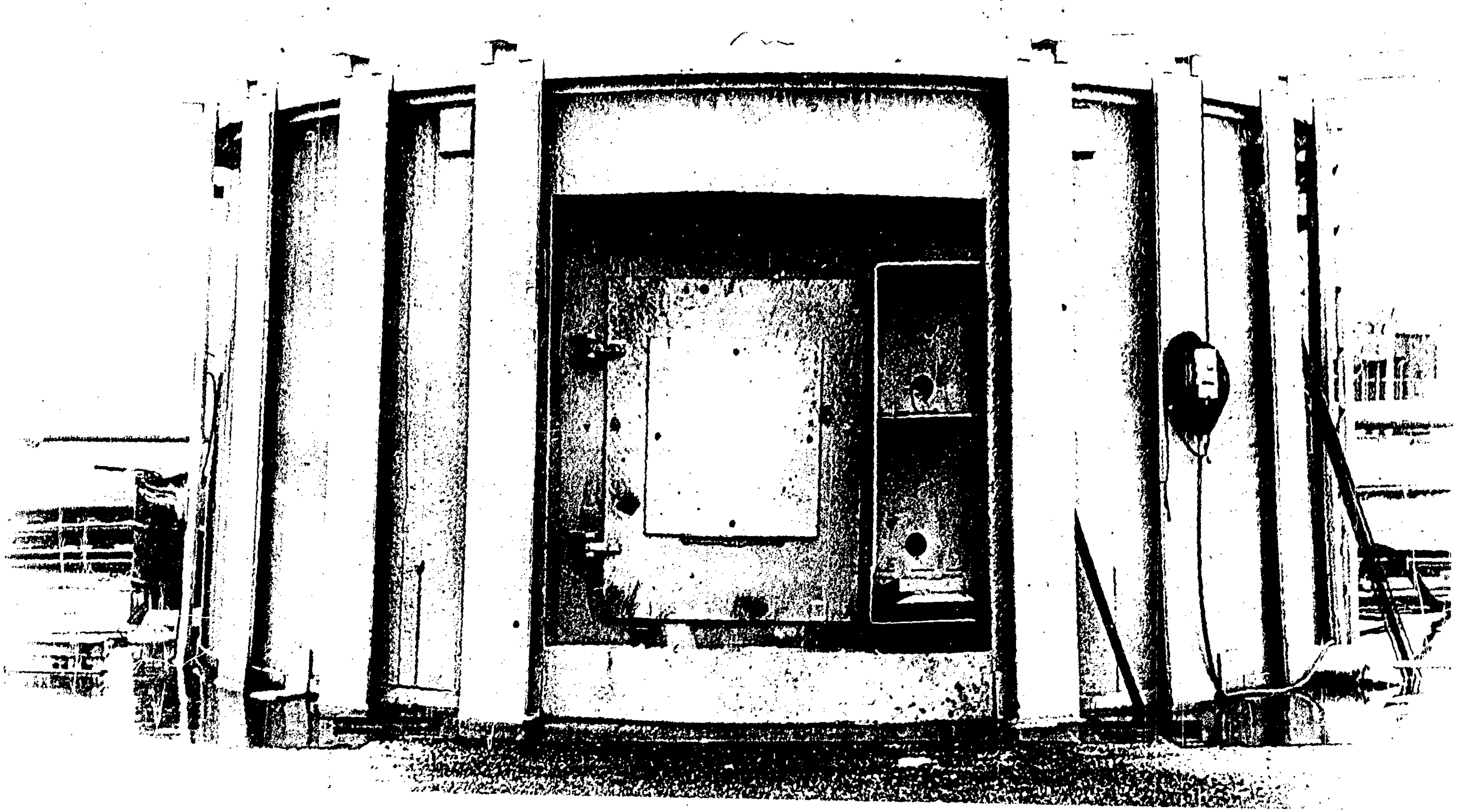
## CONCLUSIONS

A comparison of the results of these tests with the standards prescribed in reference (b) indicates the stowage of liquid-propellant BULLPUP ASM-N-7a and solid-propellant BULLPUP ASM-N-7 units in a common magazine, to the extent of placing units on the same stanchions at random, to be no more hazardous than comparable segregated stowage of liquid- or solid-propellant units. Critical safety measures which must be taken are to insure that the initiator opening of the liquid-propellant engine be closed at all times, either by means of the initiator or the shipping plug, and that adequate restraint be provided for propulsive liquid-propellant engines.

## REFERENCES


(a) NWL, Dahlgren ltr WX:HSO:cmf 8800/S of 13 February 1962
(b) NWL Tech Memo No. W-5/62

# APPENDIX A



PHD-89357-4-62

Figure 1

27 April 1962

Photograph of simulated magazine used for BULIPUP compatibility tests.

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# APPENDIX B

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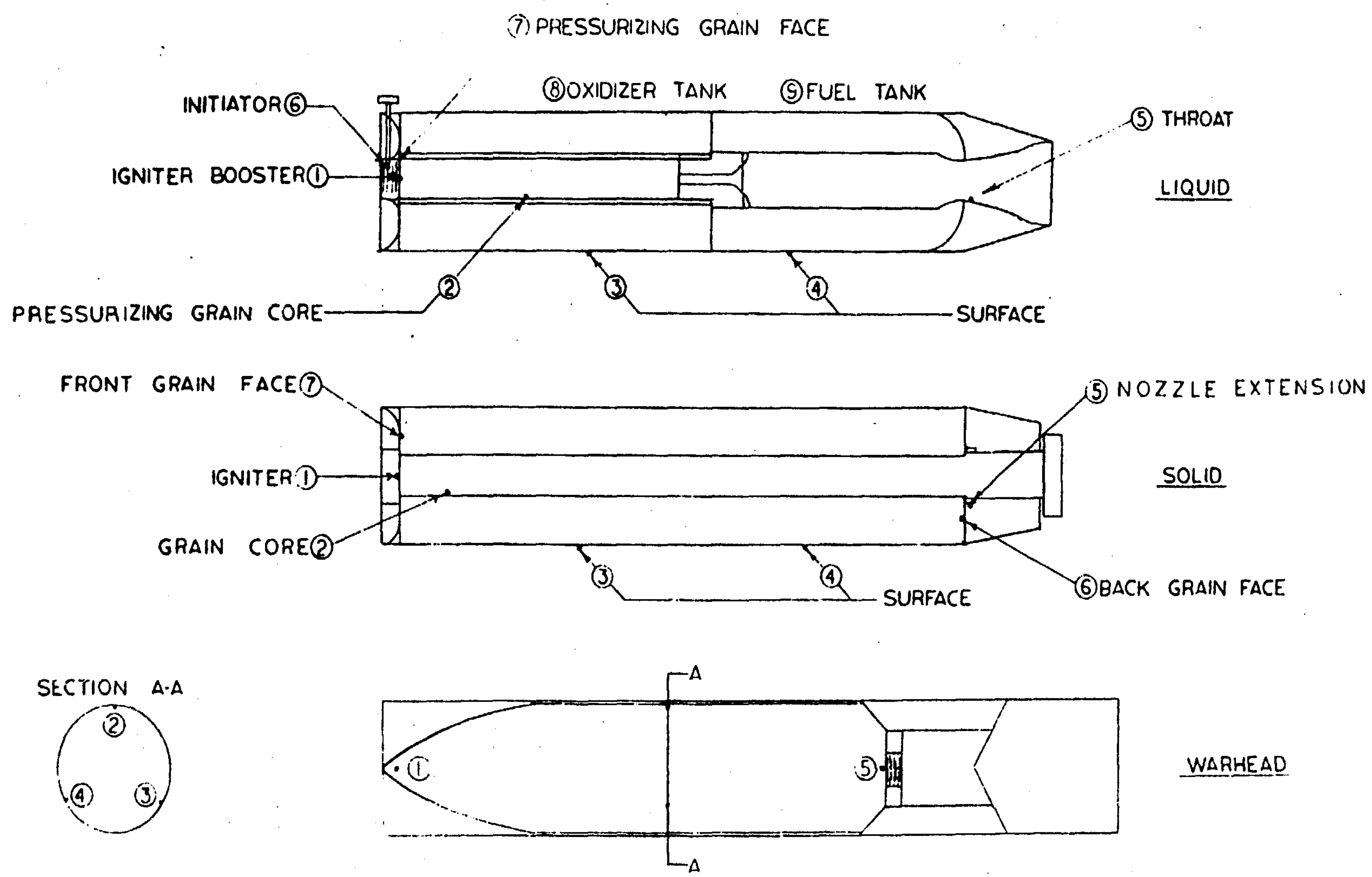
# MAGAZINE SAFETY TESTS
## LIQUID & SOLID PROPELLANT BULLPUP
### LOCATION & POSITION NO. OF THERMOCOUPLES




NOTE: NOT ALL THERMOCOUPLE LOCATIONS WERE USED IN ALL TESTS

FIGURE 2

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## TABLE I SUMMARY OF INSTRUMENTATION PROCEDURE

(1) Pressure

Magazine pressure was recorded at the overhead of the magazine directly above the active unit.

(2) Temperatures

All temperatures were recorded by galvanometer oscillograph with thermocouples at the following locations:

(a) Magazine Temperature

Magazine temperature was recorded at the same location on the overhead of the magazine as the magazine pressure and in the overhead above the passive units in tests in which a flame shield separated them.

(b) Liquid-Propellant Engine Temperatures

Thermocouple No. 1 was located on the after face of the igniter.

Thermocouple No. 2 was located on the core of the pressurizing grain and was secured to the grain.

Thermocouple No. 3 was located on the outer case surface at the IRFNA tank. This thermocouple was insulated from the air with Pyrolock.

Thermocouple No. 4 was located on the outer case surface at the MAF-1 tank. This thermocouple was insulated from the air with Pyrolock.

Thermocouple No. 5 was located in the nozzle throat of the engine behind the plastic moisture seal. (The moisture seal is a small cup-shaped plug which fits into the nozzle.)

Thermocouple No. 6 was located on the tip of the live initiator and was used only in test A-1-c.

Thermocouple No. 7 was located on the face of the grain at the forward end.

Thermocouple No. 8 was located in the oxidizer tank of a dummy used in test B-3-b-1. The oxidizer tank contained water.

Thermocouple No. 9 was located in the fuel tank of a dummy used in test B-3-b-1. The fuel tank contained water.

(c) Solid-Propellant Motor Temperature

Thermocouple No. 1 was located on the after surface of the igniter facing the grain.

Thermocouple No. 2 was located in the core of the grain and was secured to the grain.

Thermocouples Nos. 3 and 4 were located on the outer case surface of the motor. These thermocouples were one foot apart and No. 3 was forward of No. 4. These thermocouples were insulated from the air with Pyrolock.

Thermocouple No. 5 was located on the outside of the nozzle extension of the motor. The nozzle extension is the threaded lip on the after end into which the nozzle or the non-propulsive attachment (NPA) screws. This thermocouple was on the surface but was not insulated from the air. In test B-3-b-1 another thermocouple was located next to this one and insulated from the air with Pyrolock to determine the effect of insulation on the temperature recorded in this region.

Thermocouple No. 6 was located on the after end of the grain. This thermocouple was included only in tests involving a solid-propellant motor with a partial grain. This area could not be instrumented in tests using a solid-propellant motor with a complete grain.

Thermocouple No. 7 was located on the forward end of the grain.

(d) Wax-Filled Simulated Warhead Temperatures

Thermocouple No. 1 was located on the inside surface of the warhead case at the nose.

Thermocouples Nos. 2, 3, and 4 were located on the inside surface of the warhead case at 120° intervals around the periphery at a section midway between nose and base.

Thermocouple No. 5 was located on the inside face of the base plug which was installed where the fuse would normally be in a live unit.

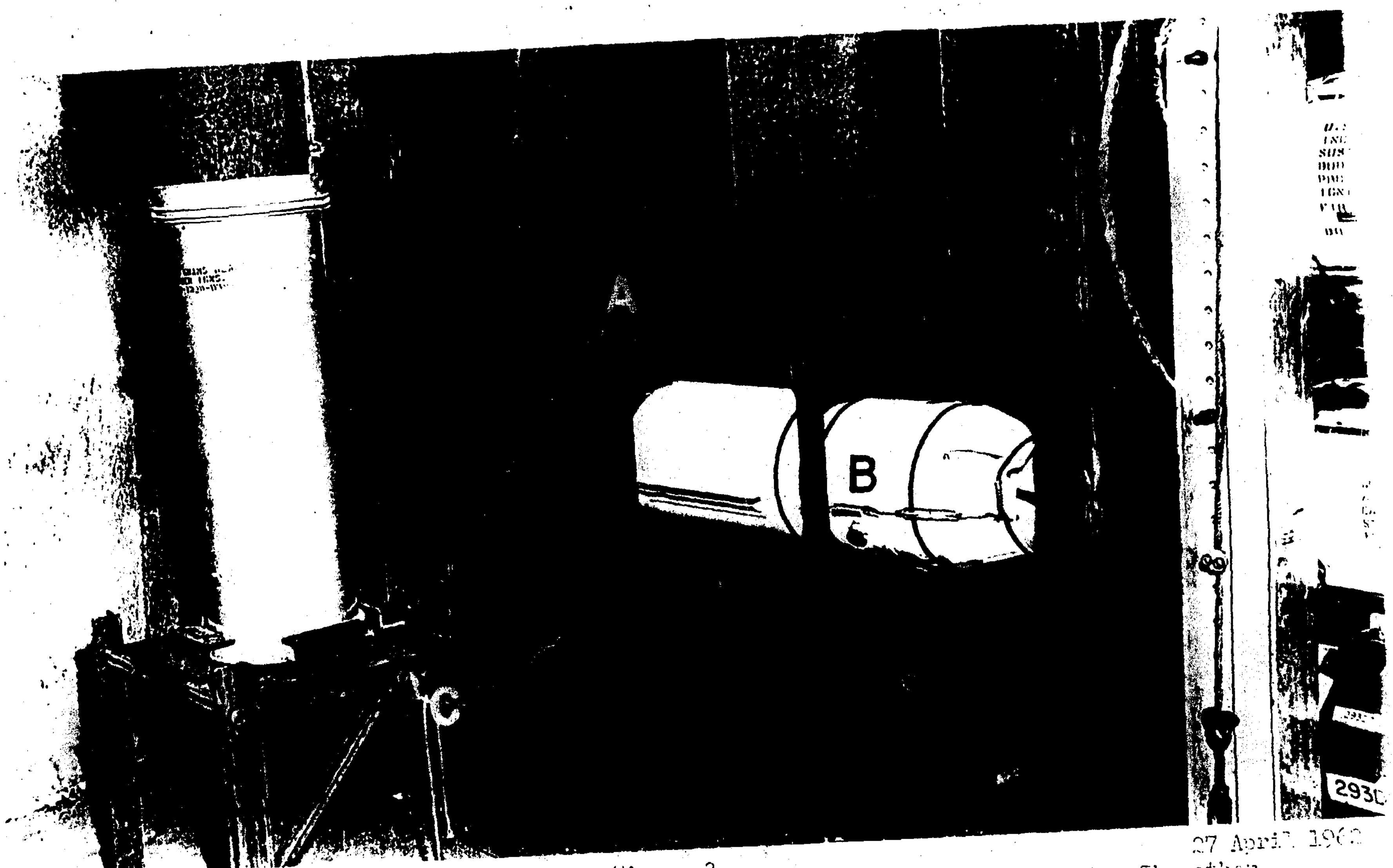
(3) Thrust

Thrust was measured with a load cell positioned forward of the active unit in tests A-1-a and A-1-b. Thrust was measured in test A-1-b when the active unit ignited.

(4) Time of Vent Cover Release

In all tests a break wire was attached to each vent cover in order to record when the vent covers released.

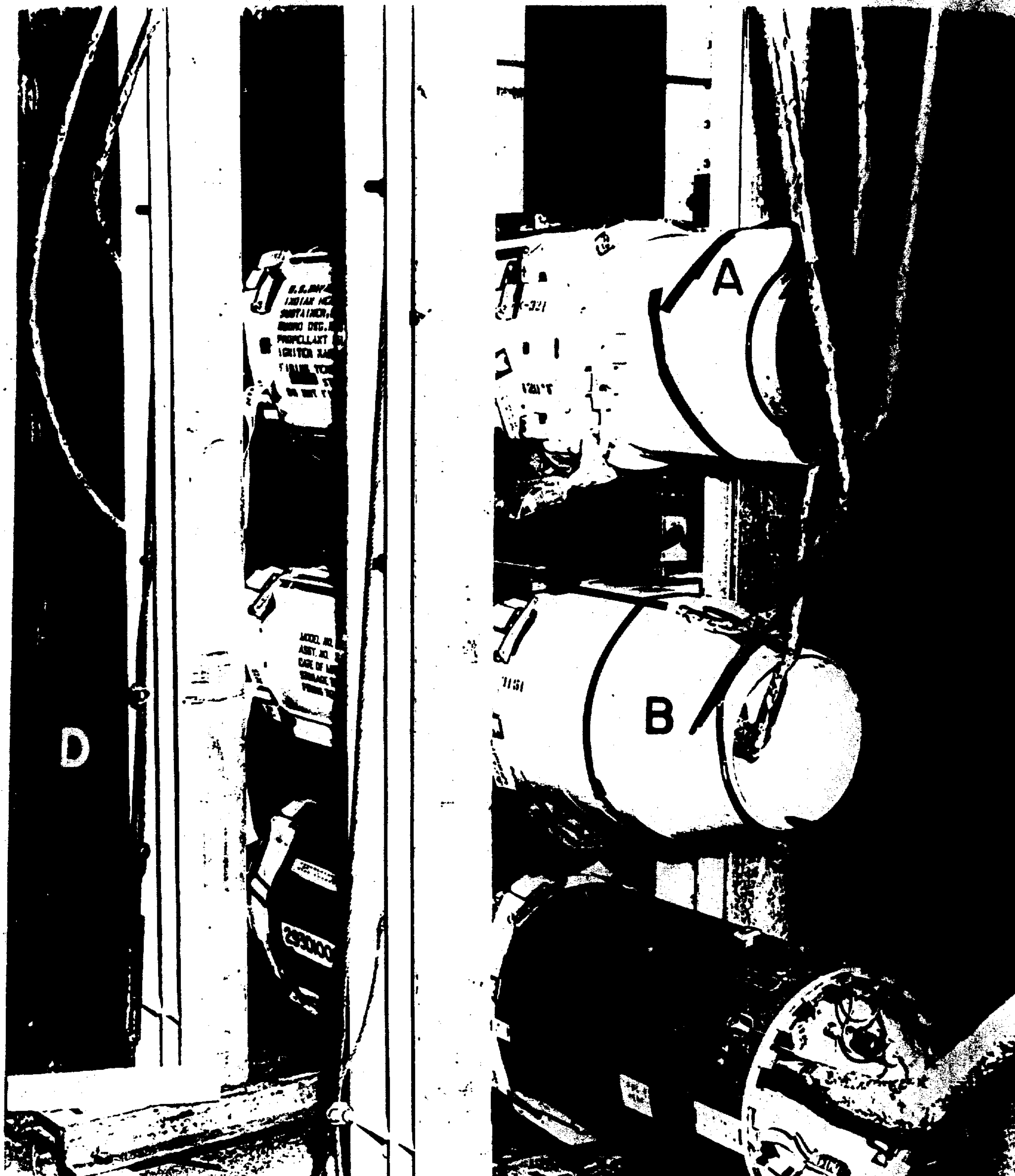
# APPENDIX C




27 April 1962

Figure 3

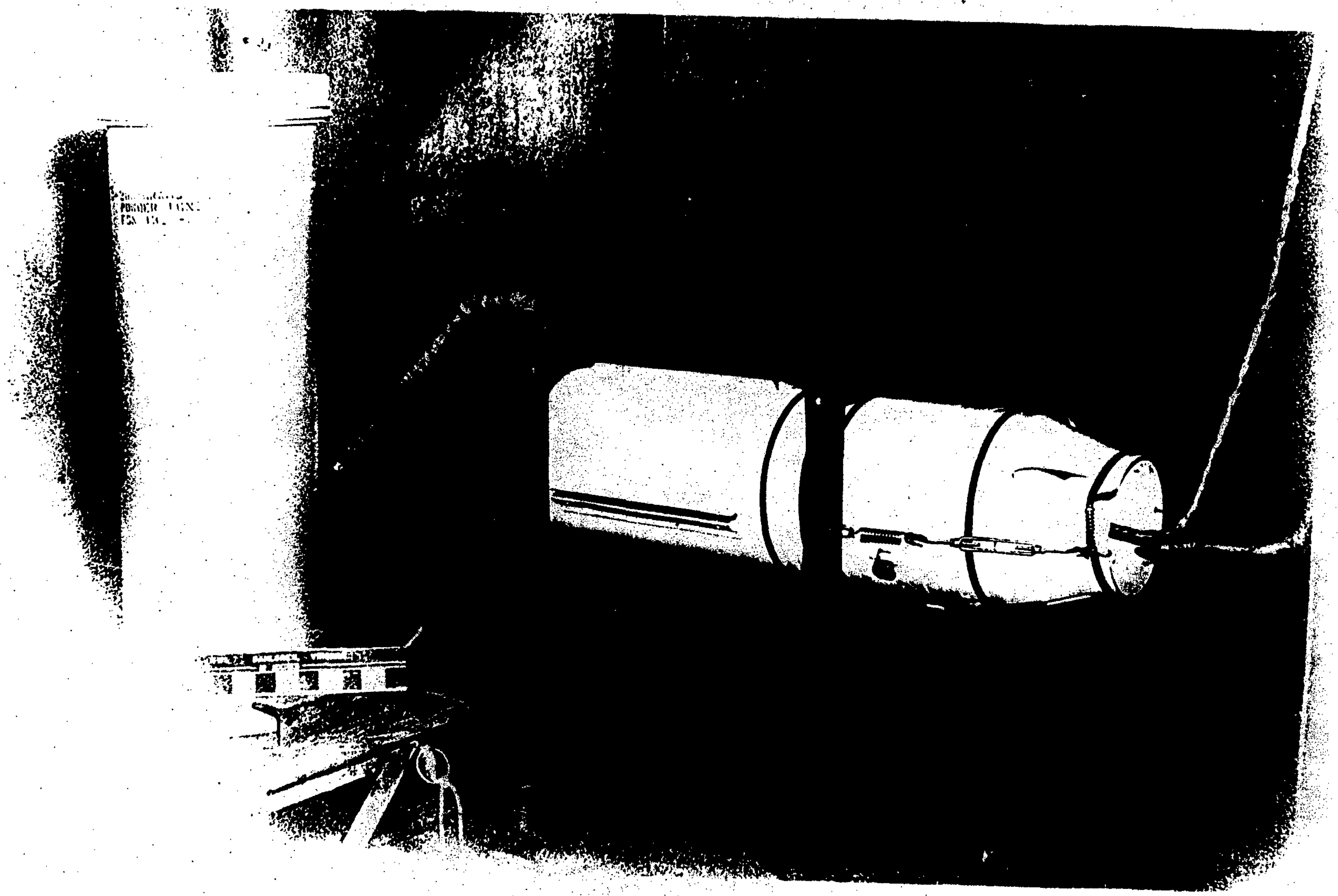
HD-59756-4-62 Test A-1-a. View of active liquid-propellant engine and one spill can before test. The other spill can cannot be seen in this picture. Note: (A) leads coming from load cell directly in front of the liquid-propellant engine, (B) spring and turnbuckle for preloading the load cell, and (C) safety pin which when removed leaves the spill platform held upright by the release cable only.




PMD-39859-4-62 Figure 4 27 April 1962

Test A-1-a. View of passive units behind bulkhead before test. (A) Solid-propellant motor, (B) liquid-propellant engine, (C) wax-filled simulated warhead and (D) bulkhead. The foil covered lines are instrumentation leads.

UNCLASSIFIED



PHD-89860-5-62

Figure 5

1 May 1962

Test A-1-b. View of active liquid-propellant engine and spill cans before test.

UNCLASSIFIED

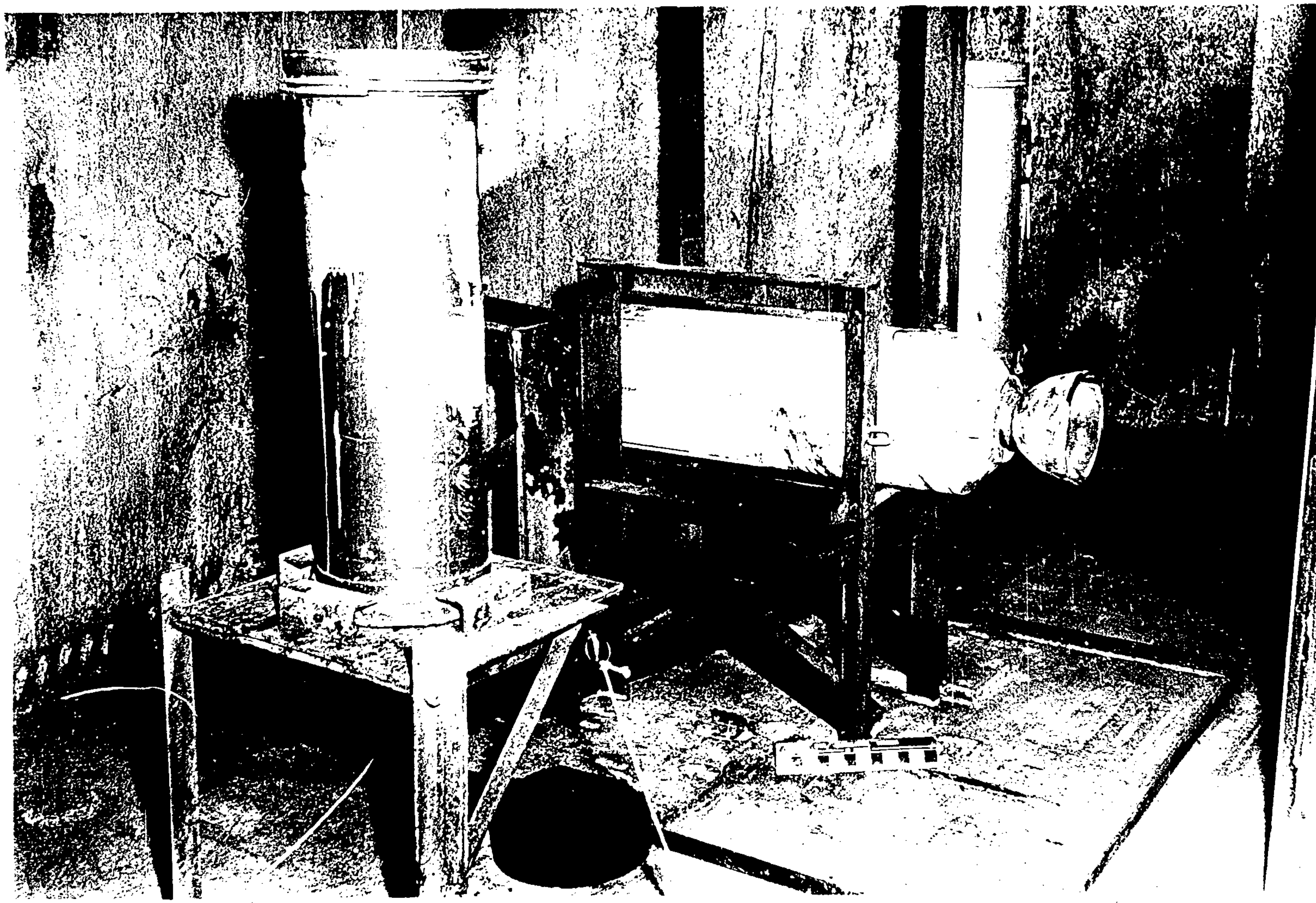
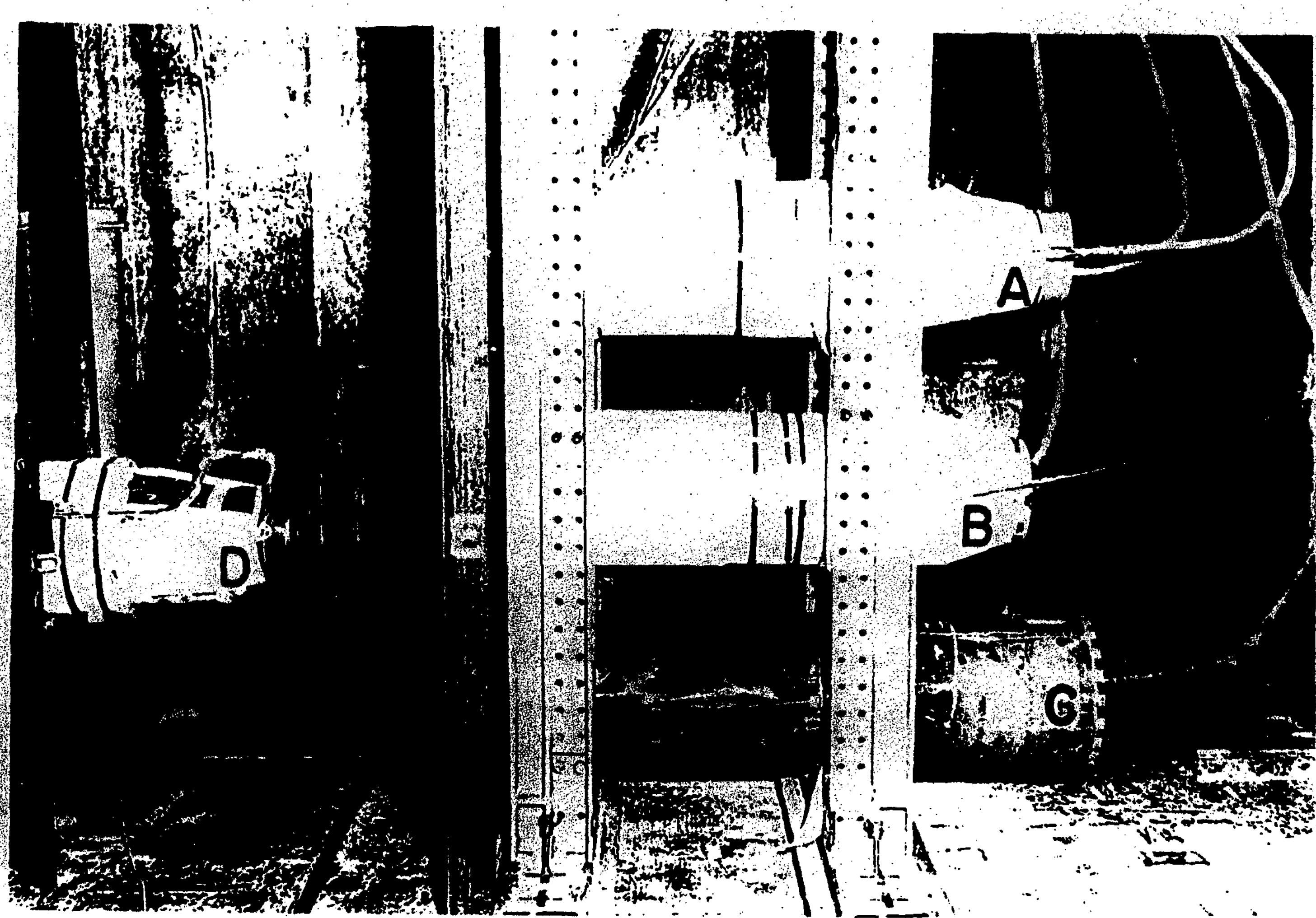




Figure 7



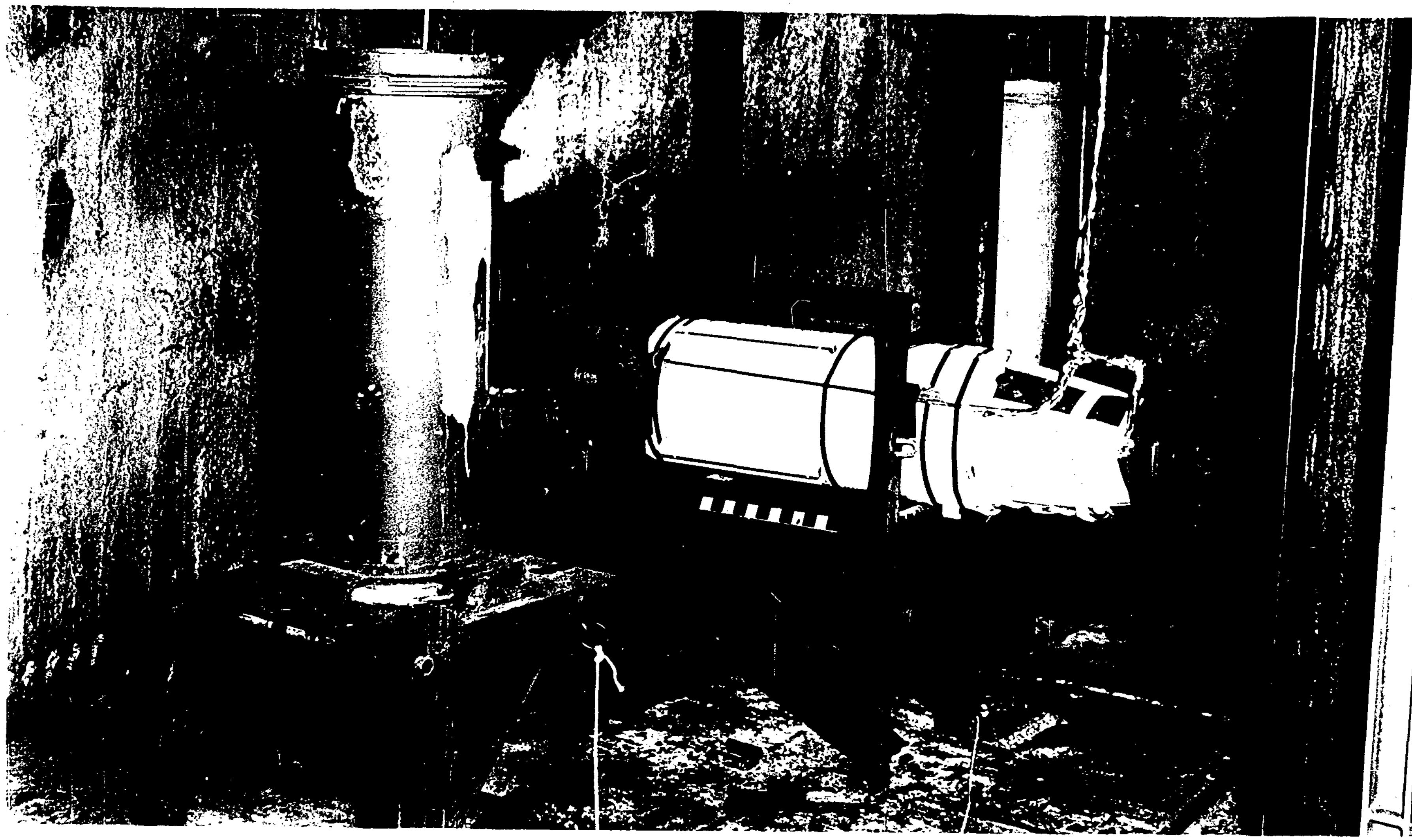
Test A-1-c. View of empty engine containing a live initiator before test. No passive units were included in this test.




[illegible]-9?63-5-62 Figure 8 15 May 1962

Test A-2-a. View of active and passive units before test. (A) Passive solid-propellant motor, ( ) passive liquid-propellant engine, (G) wax-filled simulated warhead, (D) active solid-propellant engine, and ( ) bulkhead.

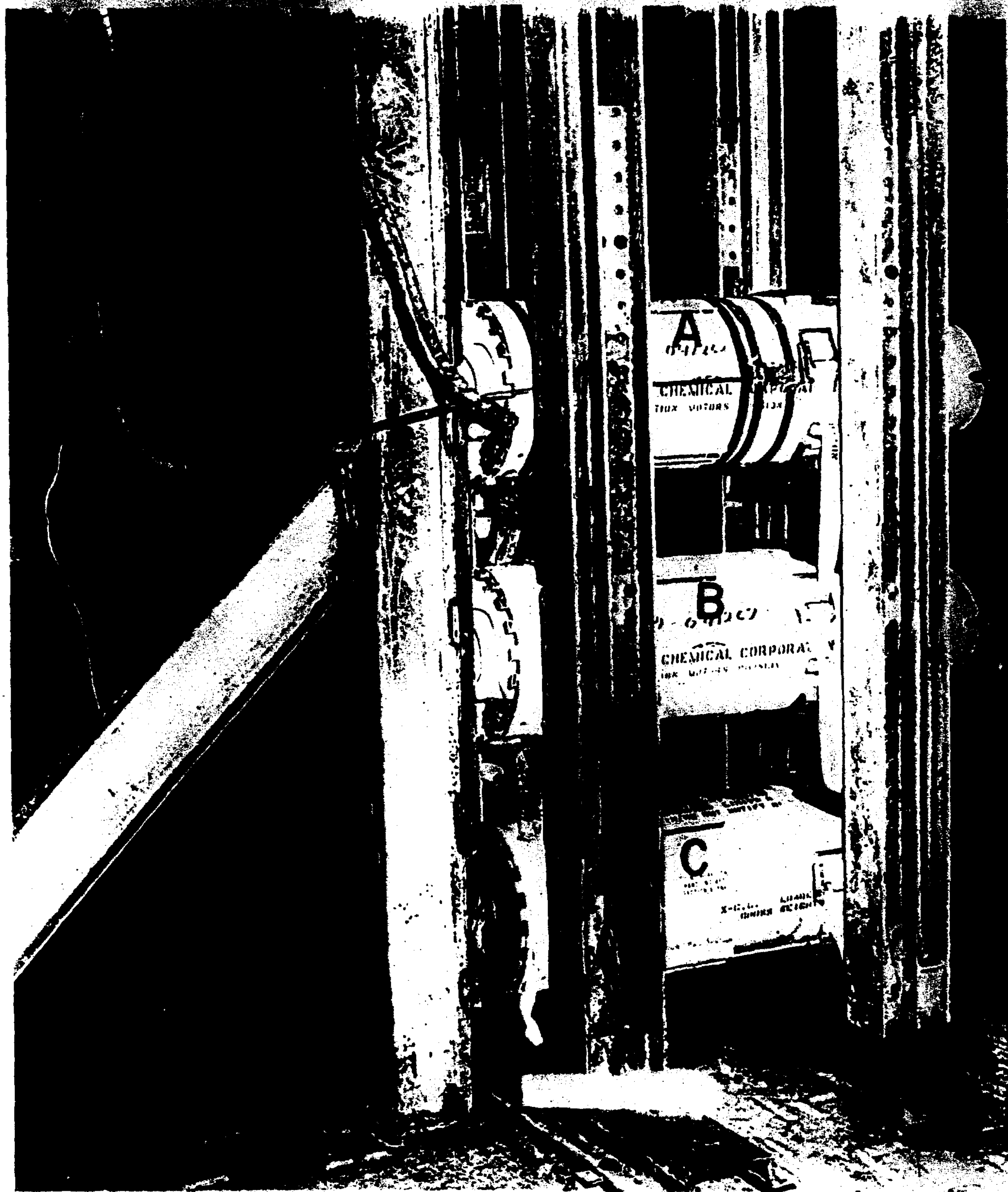
UNCLASSIFIED



PHD-89864-5-62 | Figure 9 | 16 May 1962

Test A-2-b. View of active solid-propellant engine and spill cans before test. Three passive units, the same as in test A-2-a, are positioned behind the bulkhead to the right.

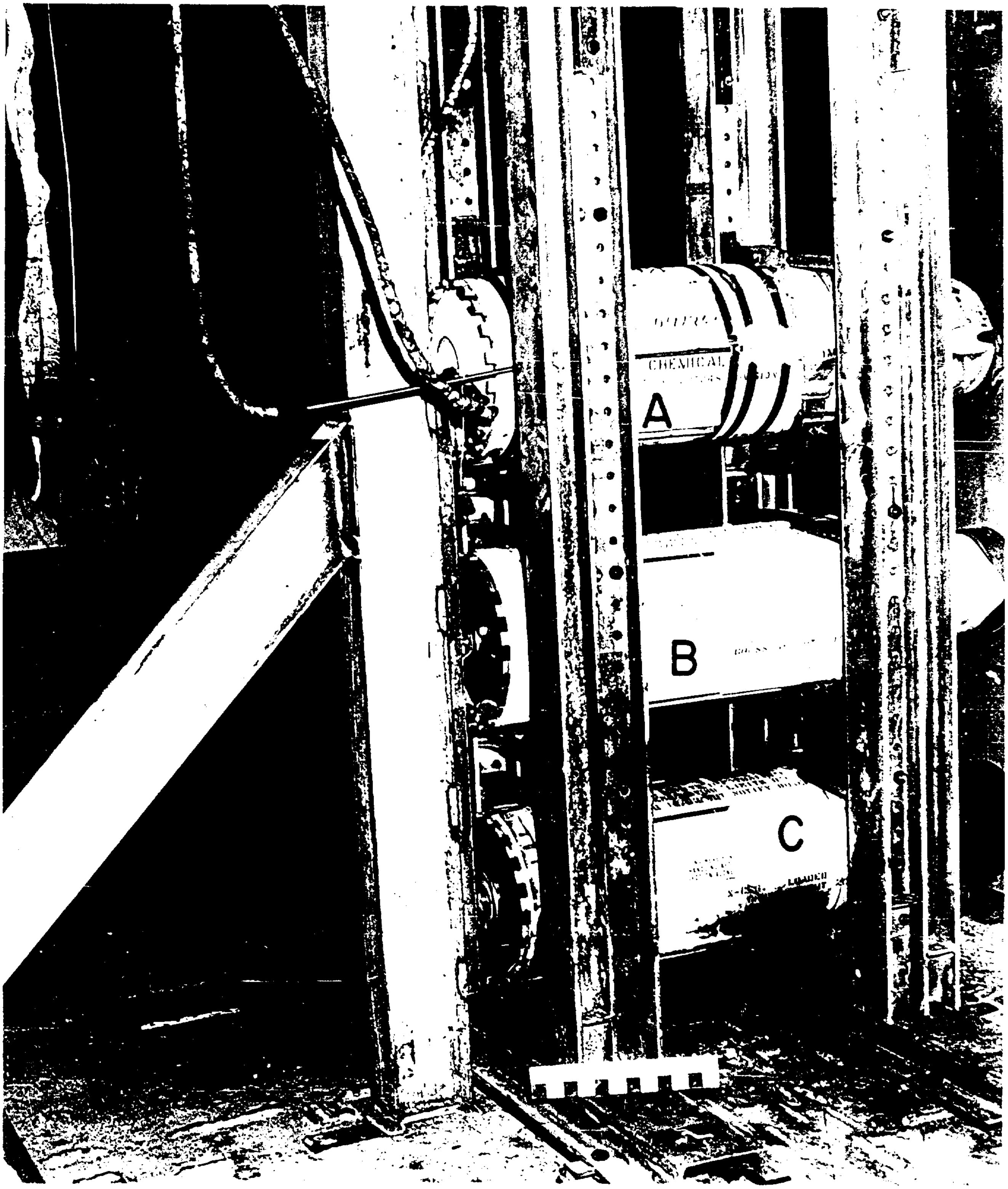
UNCLASSIFIED




PHD-89865-5-62 Figure 10 29 May 1962

Test B-1-a (Mod). View of arrangement before test. (A) Passive liquid-propellant engine, (B) active liquid-propellant engine and (C) passive solid-propellant motor containing a 4-inch grain segment in the after end. The 6-inch I beam running from the deck to the overhead was included in the test arrangement to restrain the propulsive active liquid-propellant engine.

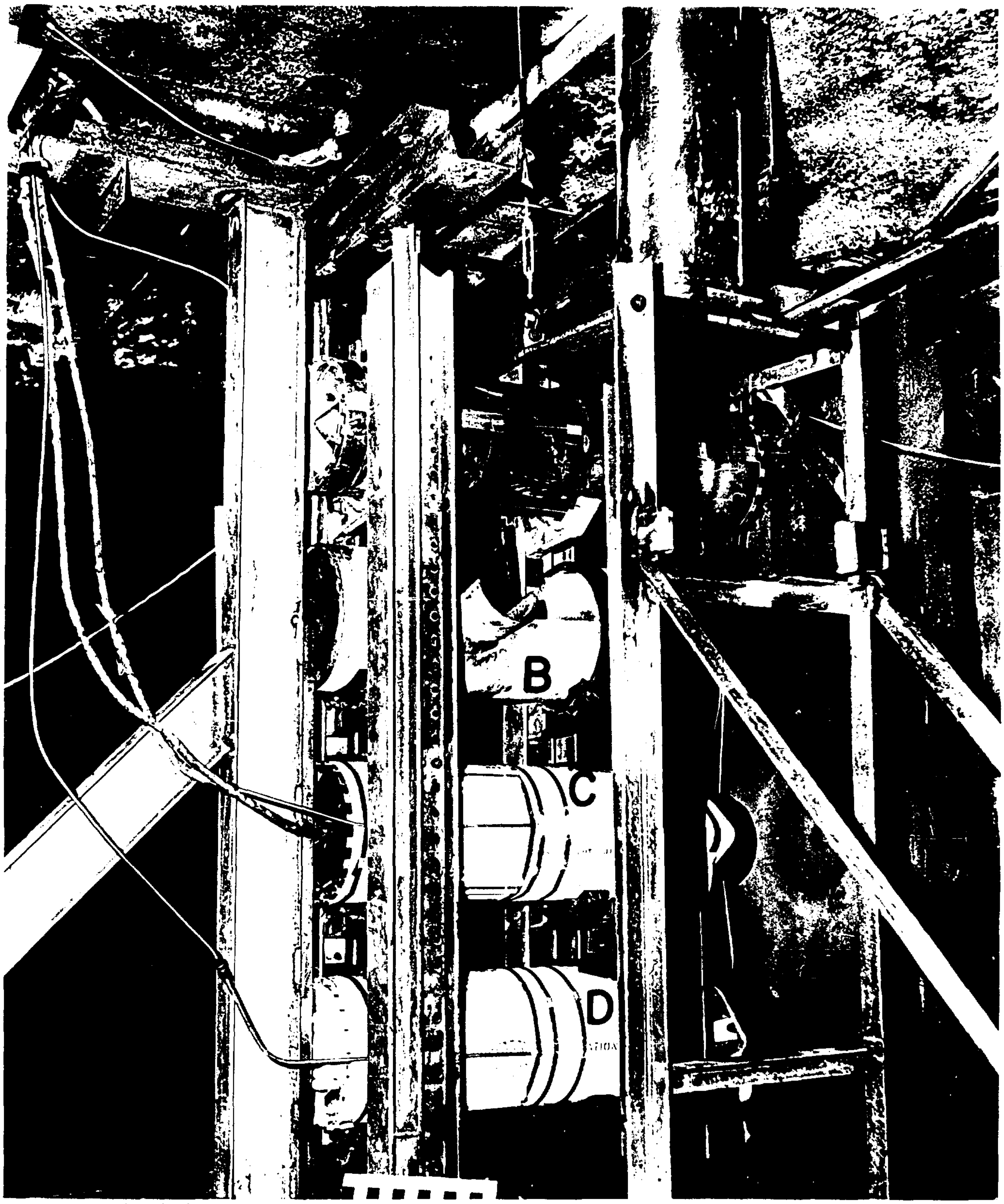
UNCLASSIFIED




PHD-89866-6-62 Figure 11 5 June 196[illegible]

Test B-2-a (Mod). View of arrangement before test. (A) Passive liquid-propellant engine, (B) active solid-propellant motor, and (C) passive solid-propellant motor containing a 4-inch grain segment in the after end.

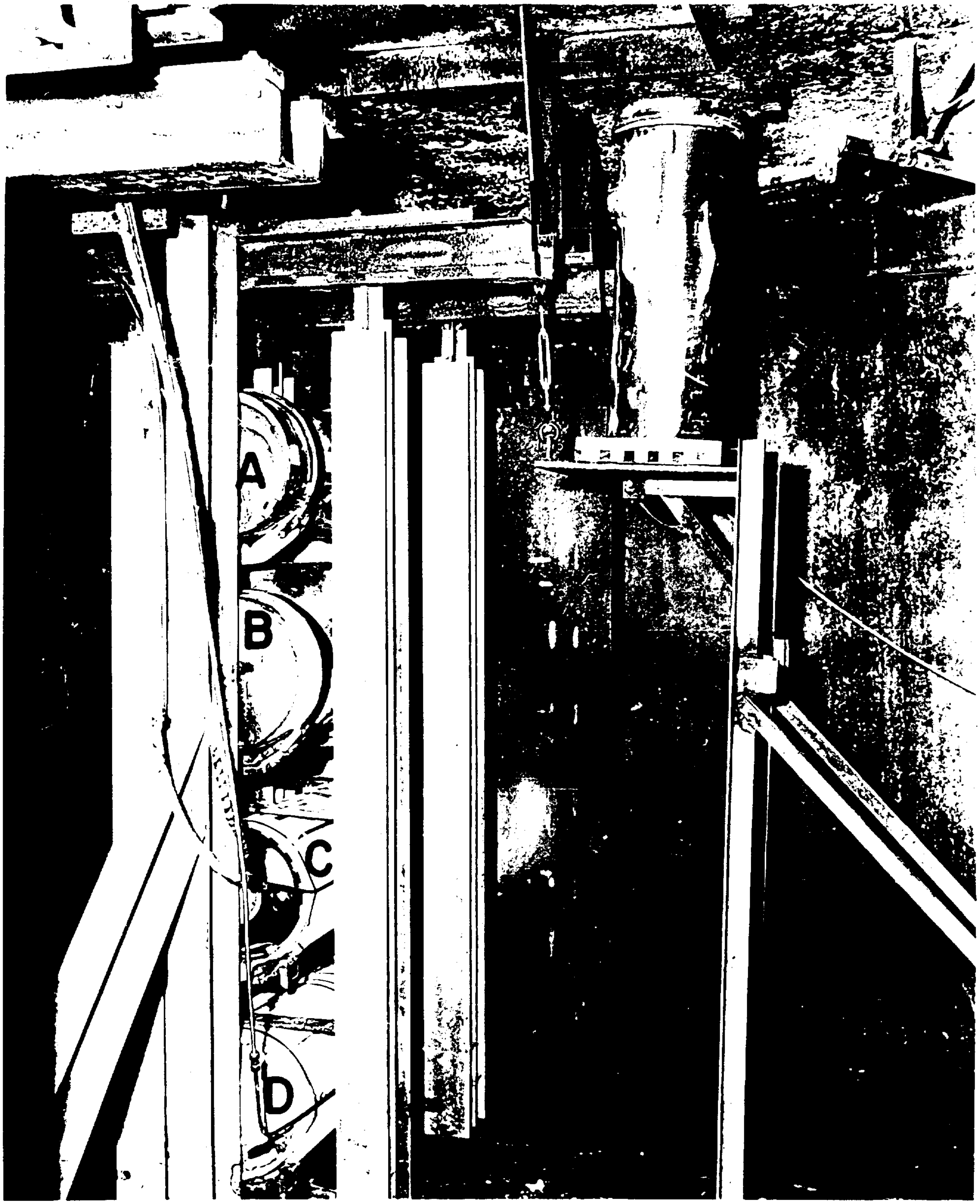
UNCLASSIFIED




PHD-89867-6-62 Figure 12 12 June 1962

Test B-3-a. View of arrangement before test. (A) Wax filled simulated warhead, (B) dummy designed to provide leakage when the propellants are poured into it, (C) passive solid-propellent motor, and (D) passive liquid-propellant engine. The can on the other side of the units cannot be seen in this picture.

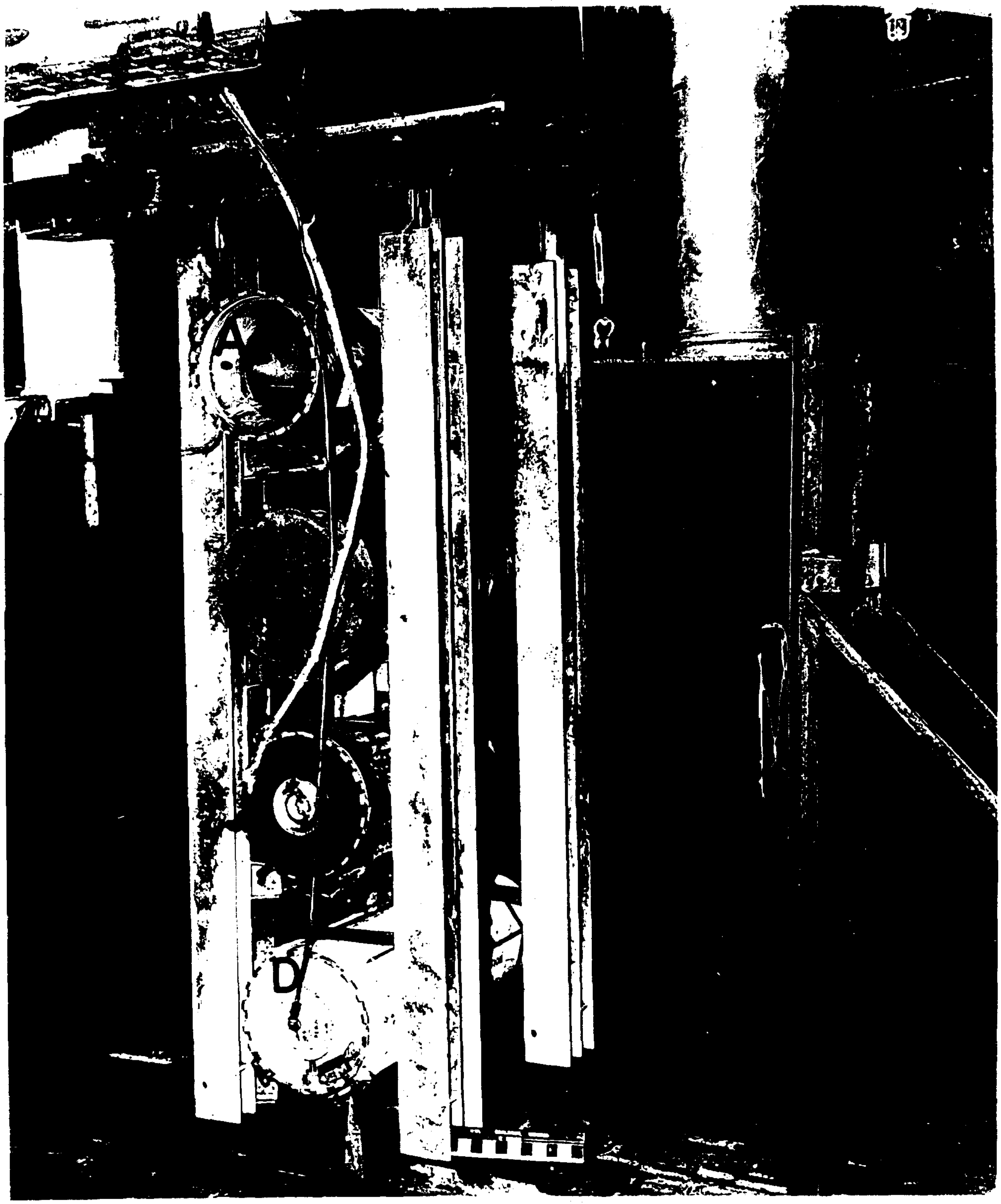
UNCLASSIFIED




PHD-89868-6-62 Figure 13 13 June 1962

Test B-3-b. View of arrangement before test. (A) Wax filled simulated warhead, (B) dummy designed to provide leakage when the propellants are poured into it, (C) passive solid-propellant motor, and (D) passive liquid-propellant engine. The can to the left of the units cannot be seen in this picture.

UNCLASSIFIED




PHD-89869-6-62 Figure 14 29 June 1962

Test B-3-b-1. View of arrangement before test. (A) Wax filled simulated warhead, (B) dummy designed to provide leakage when the propellants are poured into it, (C) passive solid-propellant motor containing only a 4-inch grain segment, and (D) passive dummy liquid-propellant engine containing water in the fuel and oxidizer tanks.

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APPENDIX D

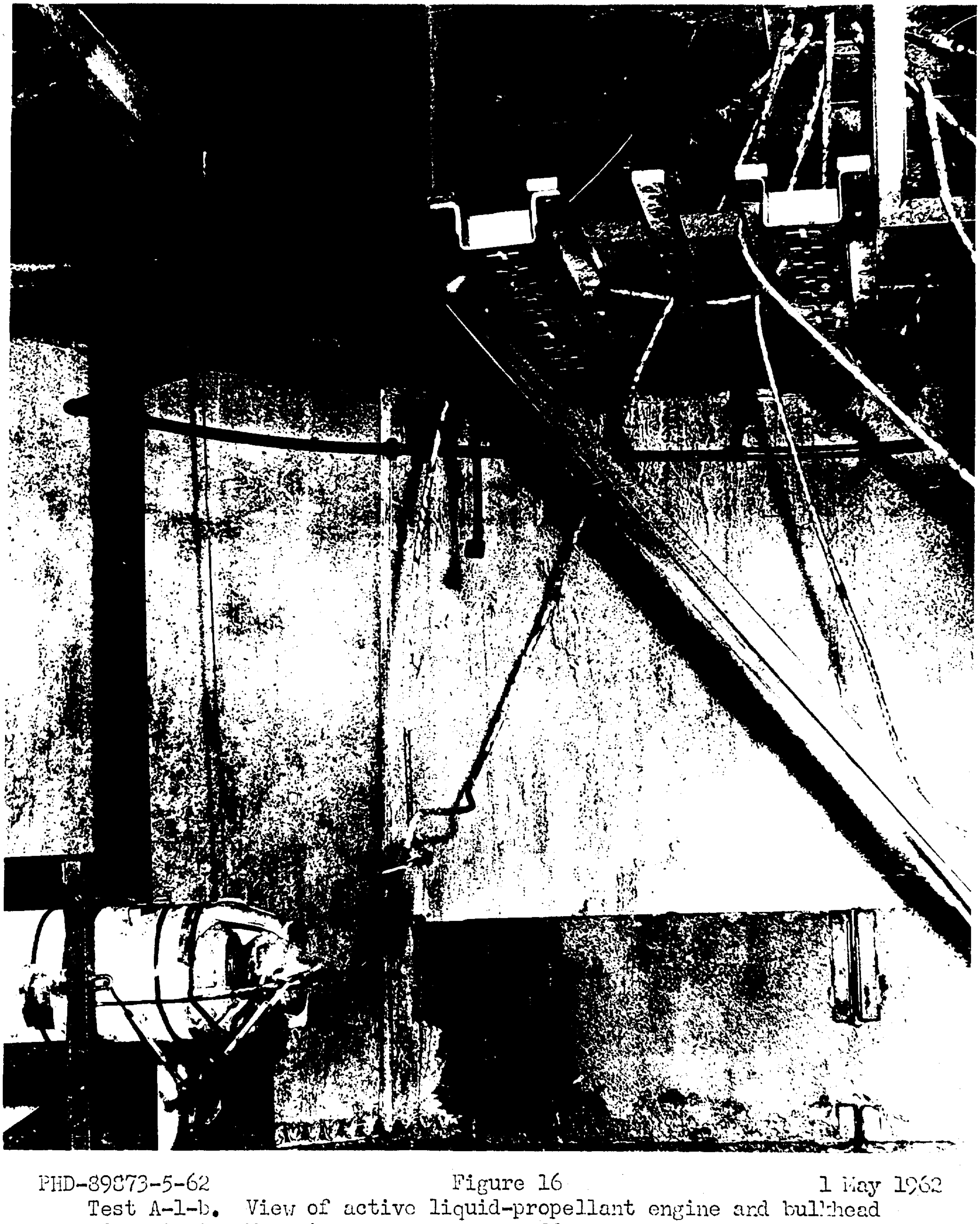

PHD-39870-4-62

Figure 15

27 April 1962

Test A-1-a. View of active liquid-propellant engine, spill cans, and passive units after test. Note sagging of aluminum nozzle shroud due to the heat environment created by the burning propellants.

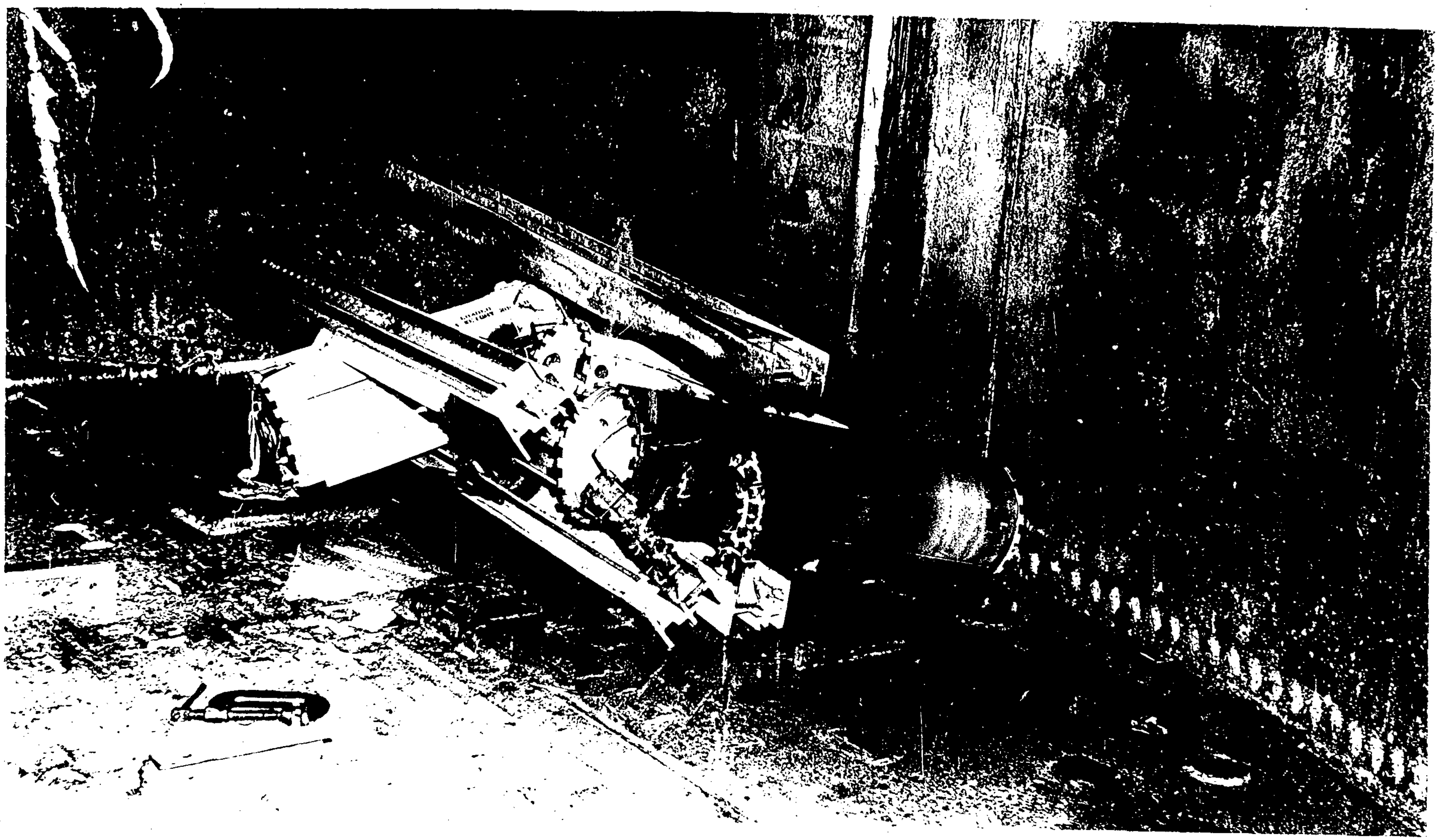
UNCLASSIFIED



PHD-89873-5-62 Figure 16 1 May 1962

Test A-1-b. View of active liquid-propellant engine and bulkhead after test. Magazine pressure was sufficient to raise the overhead and break the angle irons to which the bulkhead was welded. The blast from the burning engine then blew the bulkhead and the passive units away.

UNCLASSIFIED



PHD-89871-5-62

Figure 17

1 May 1962

Test A-1-b. View of the passive units as they came to rest in the corner of the magazine. These units were only slightly damaged and did not ignite.

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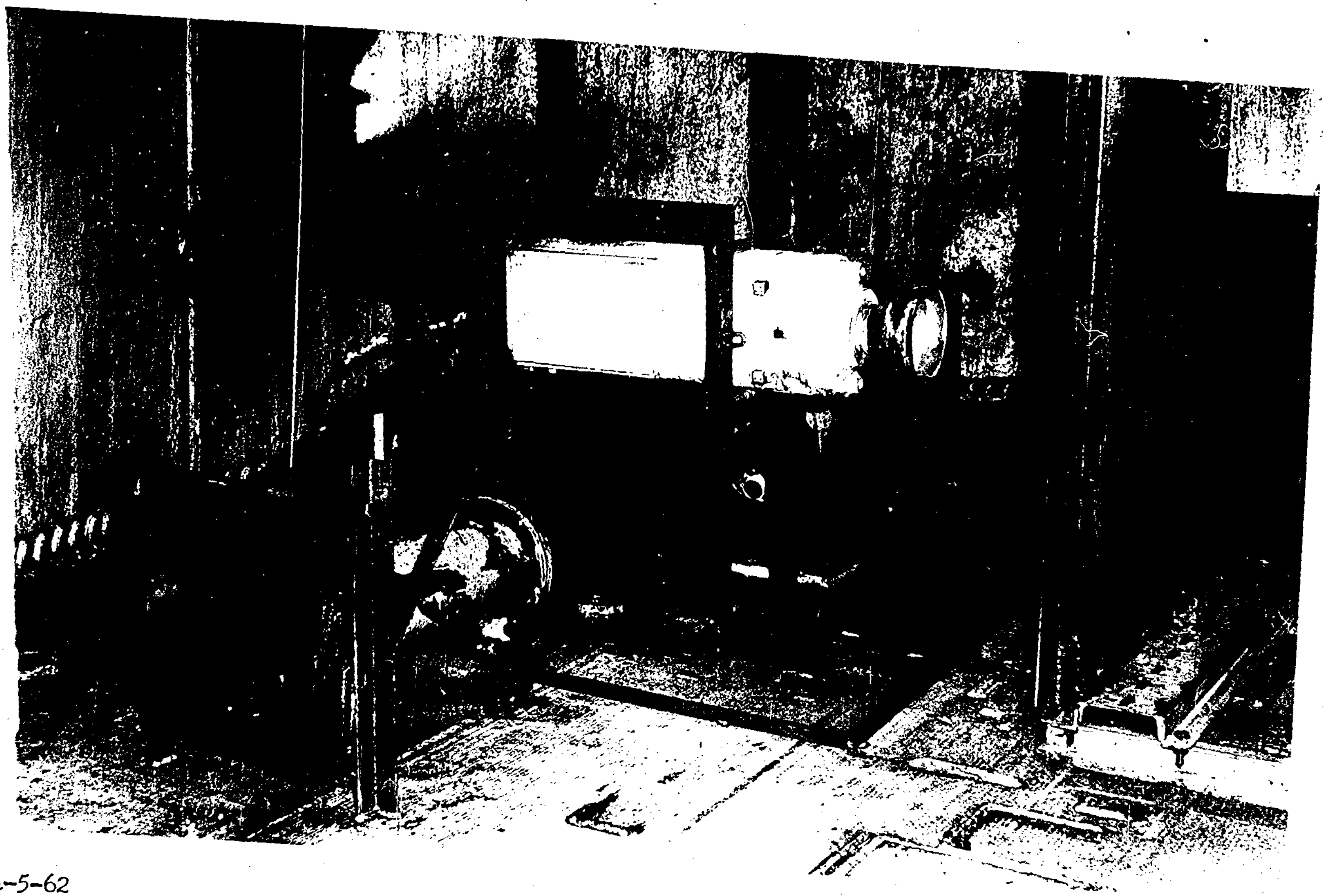
PHD-89872-5-62 Figure 18 1 May 1962

Test A-1-b. View of the initiator opening of the active liquid-propellant engine after test. Note how the opening was enlarged by the gas venting from this opening as well as the nozzle.



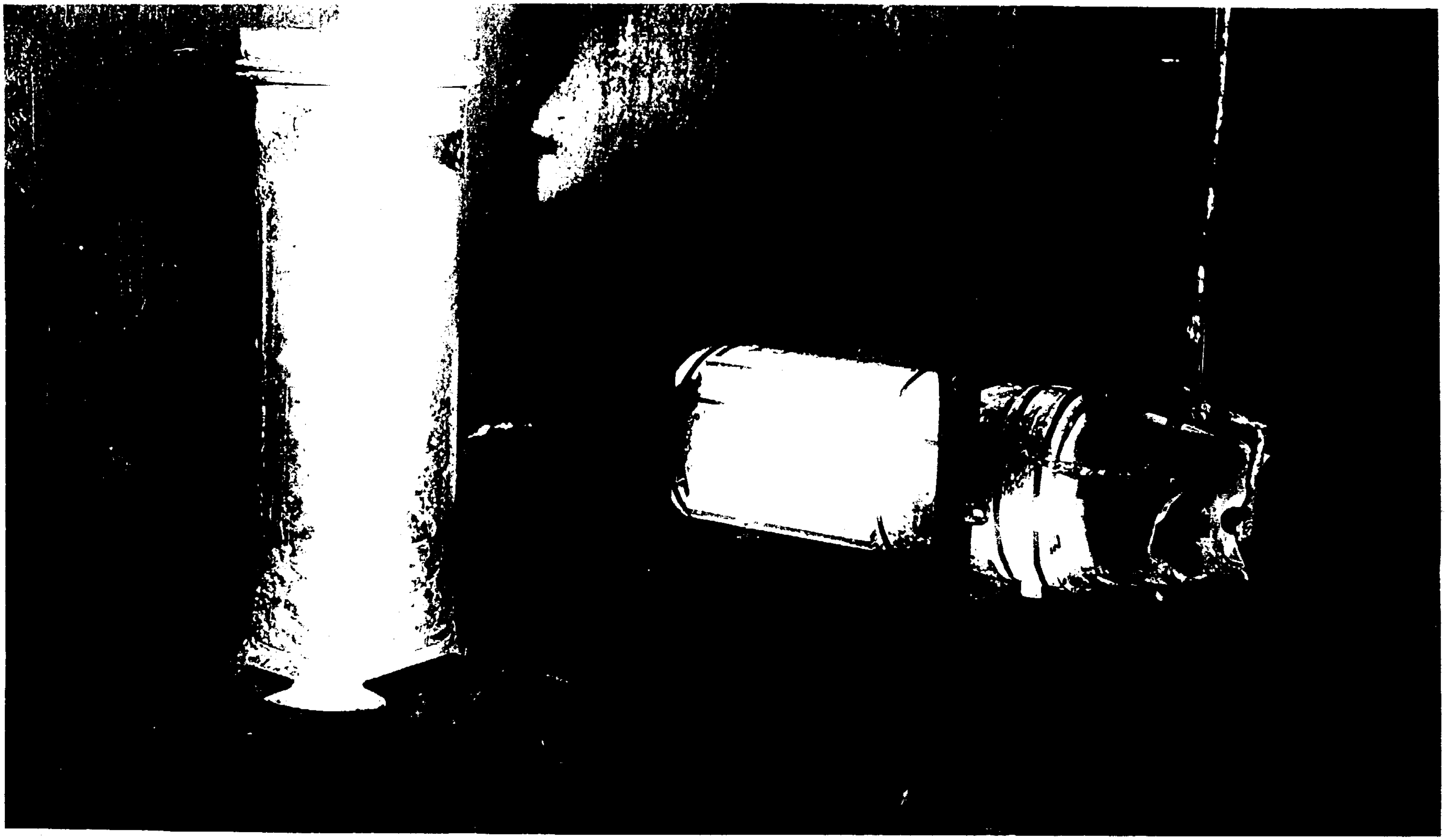
PHD-89874-5-62

Figure 19

11 May 1962

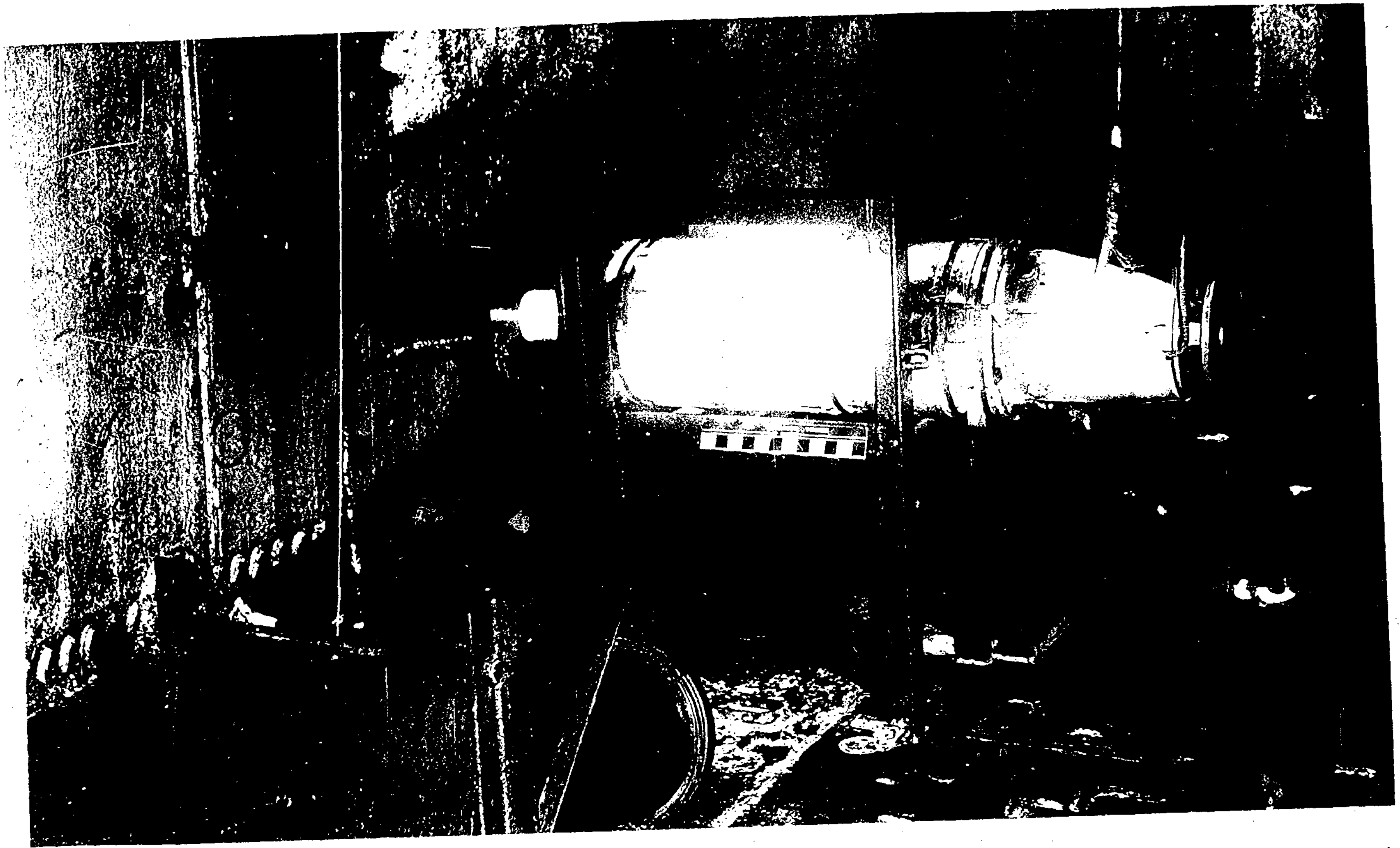
Test A-1-c. View of the empty engine containing a live initiator after test.

UNCLASSIFIED



PHD-39875-5-62 Figure 20 15 May 1962

Test A-2-a. View of active solid-propellant motor after test. The spill cans had been righted before this picture was taken.



PHD-89876-5-62

Figure 21

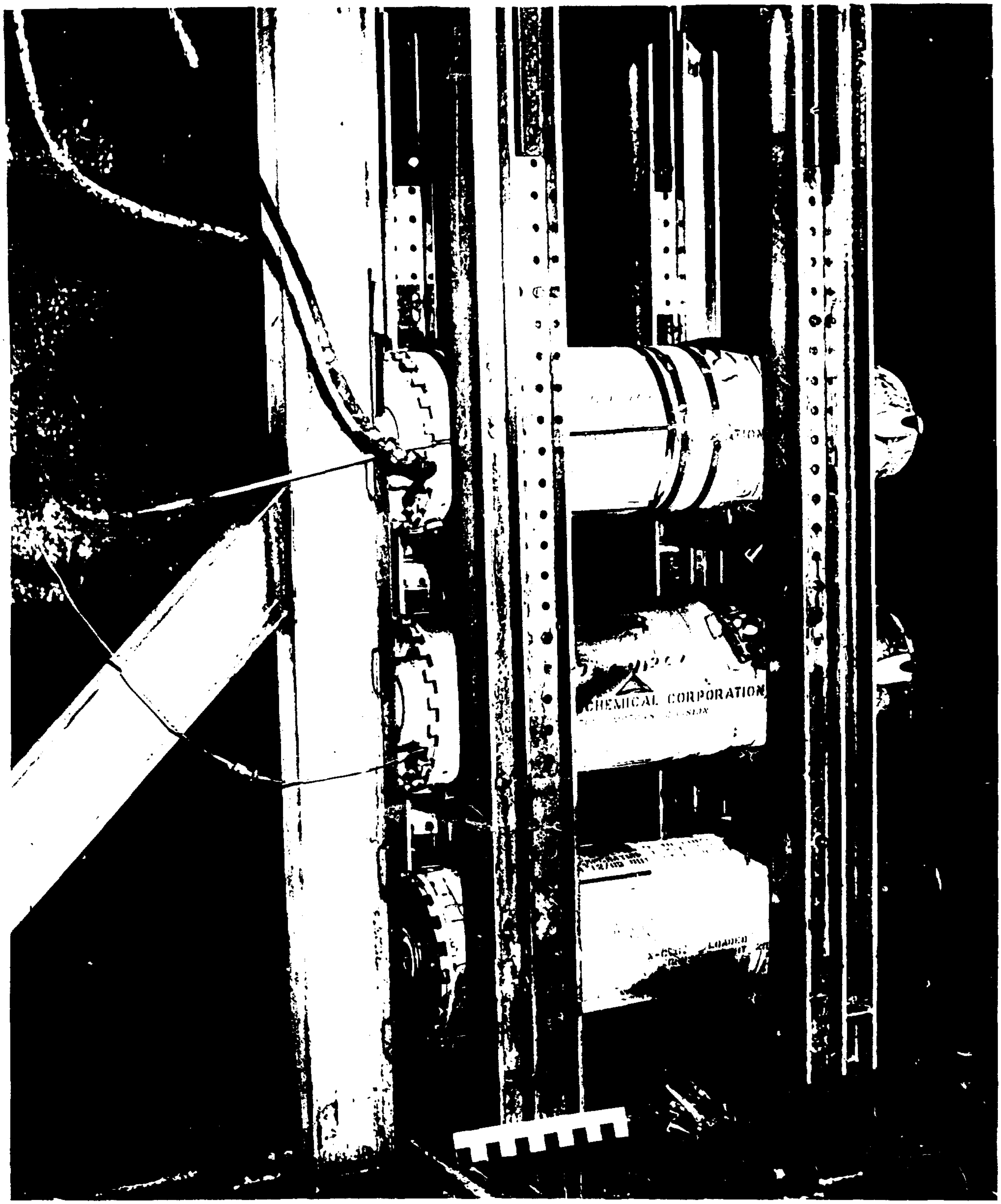
16 May 1962

Test A-2-b. View of active solid-propellant motor and spill cans after test.

UNCLASSIFIED

PHD-89877-5-62 Figure 22 16 May 1962

Test A-2-b. View of the passive units after test. Note blistering of paint on the nozzle shroud of the passive liquid-propellant engine.




PHD-89878-5-62 Figure 23 29 May 1962

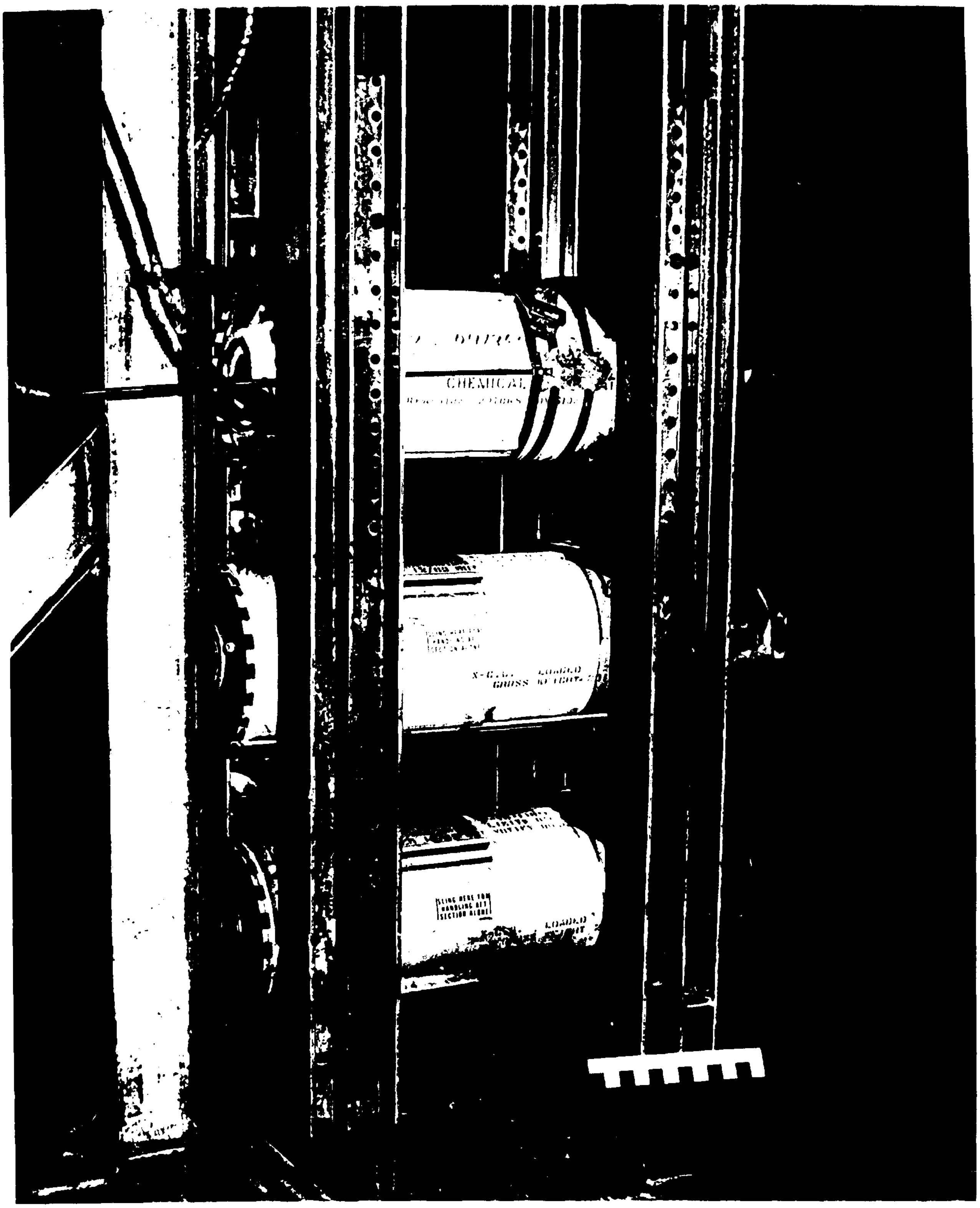
Test B-1-a (MOD). View of arrangement after test. Note that the nylon tie-down strap is burned away.

UNCLASSIFIED

PHD-89879-5-62 Figure 24 29 May 1962

Test B-1-a (MOD). View of the 3/16" steel bulkhead after test. This bulkhead was 14" from the nozzle of the active liquid-propellant engine.

UNCLASSIFIED




PHD-89880-6-62 Figure 25 5 June 1962

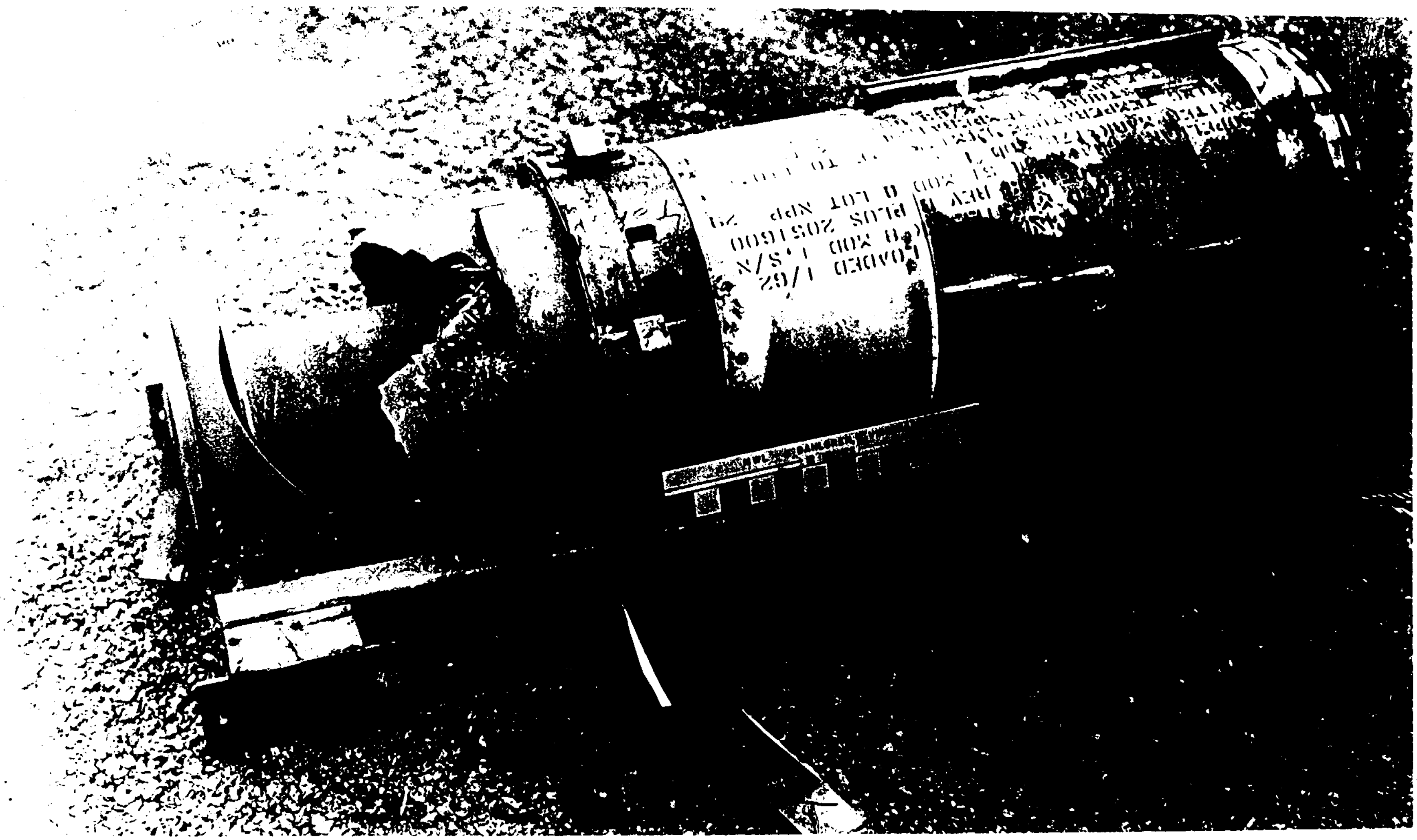
Test B-2-a (MOD). View of the arrangement after test. Note that the nozzle shroud was burned away from the passive liquid-propellant engine above the active unit and the non-propulsive attachments' (NPA) closure was dislodged from the passive solid-propellant motor below the active unit.

UNCLASSIFIED


PHD-89881-6-62 Figure 26 5 June 1962

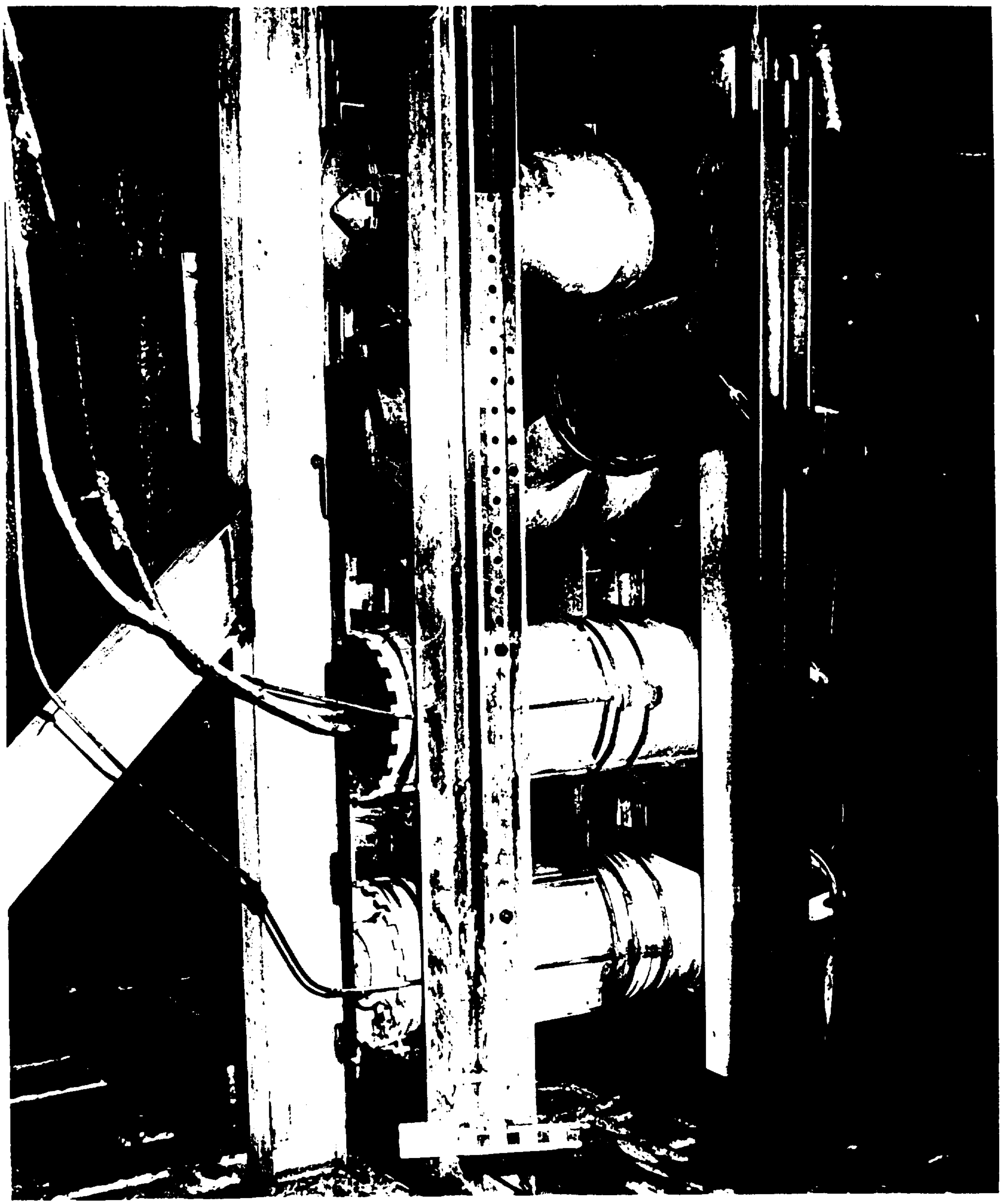
Test B-2-a (MOD). View of the passive liquid-propellant engine (stowed above the active unit) after test.

UNCLASSIFIED



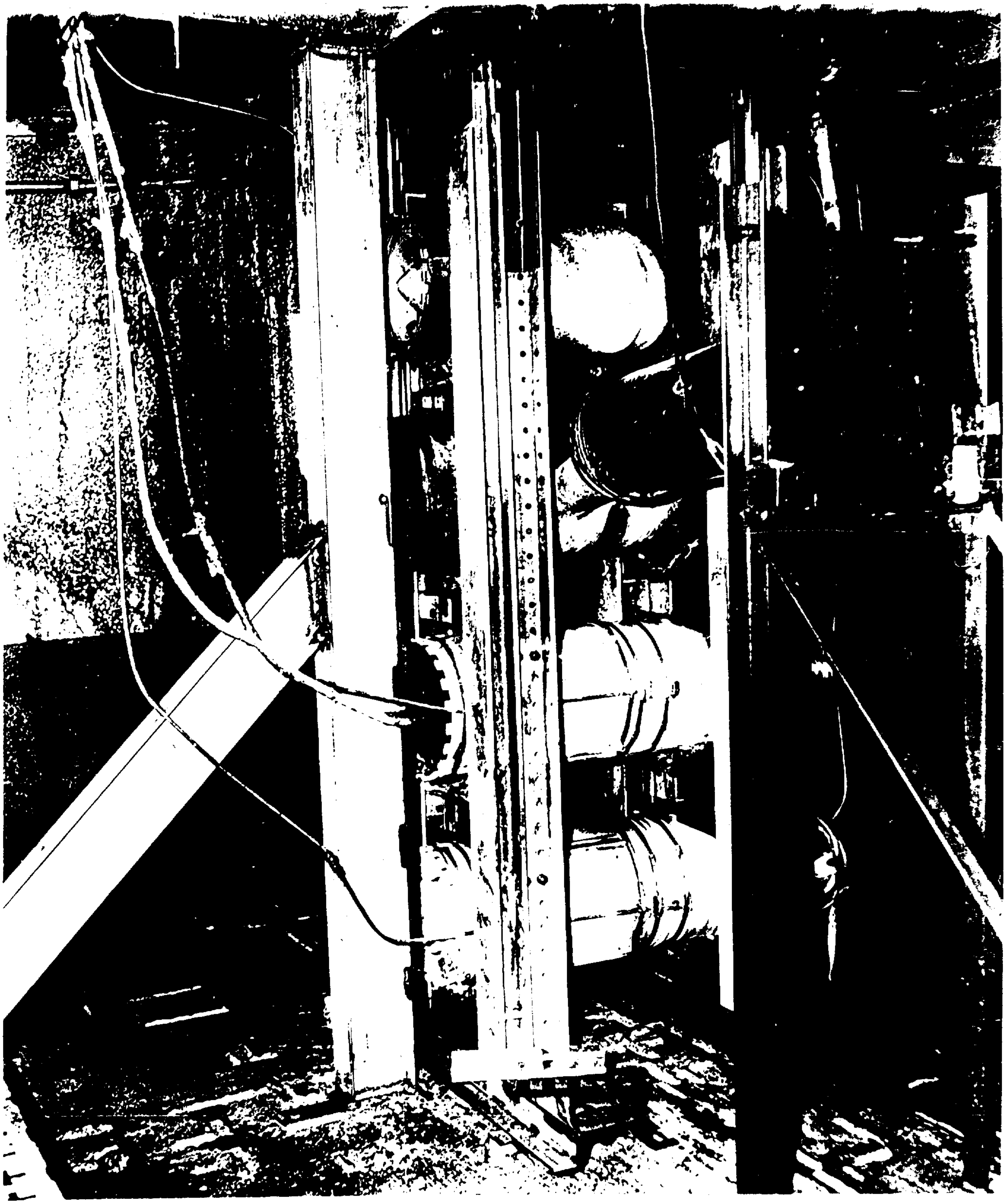
PHD-89882-6-62 Figure 27 5 June 1962

Test B-2-a (MOD). View of the passive solid-propellant motor (stowed below the active unit) after test.



PHD-89883-6-62 Figure 28 12 June 1962

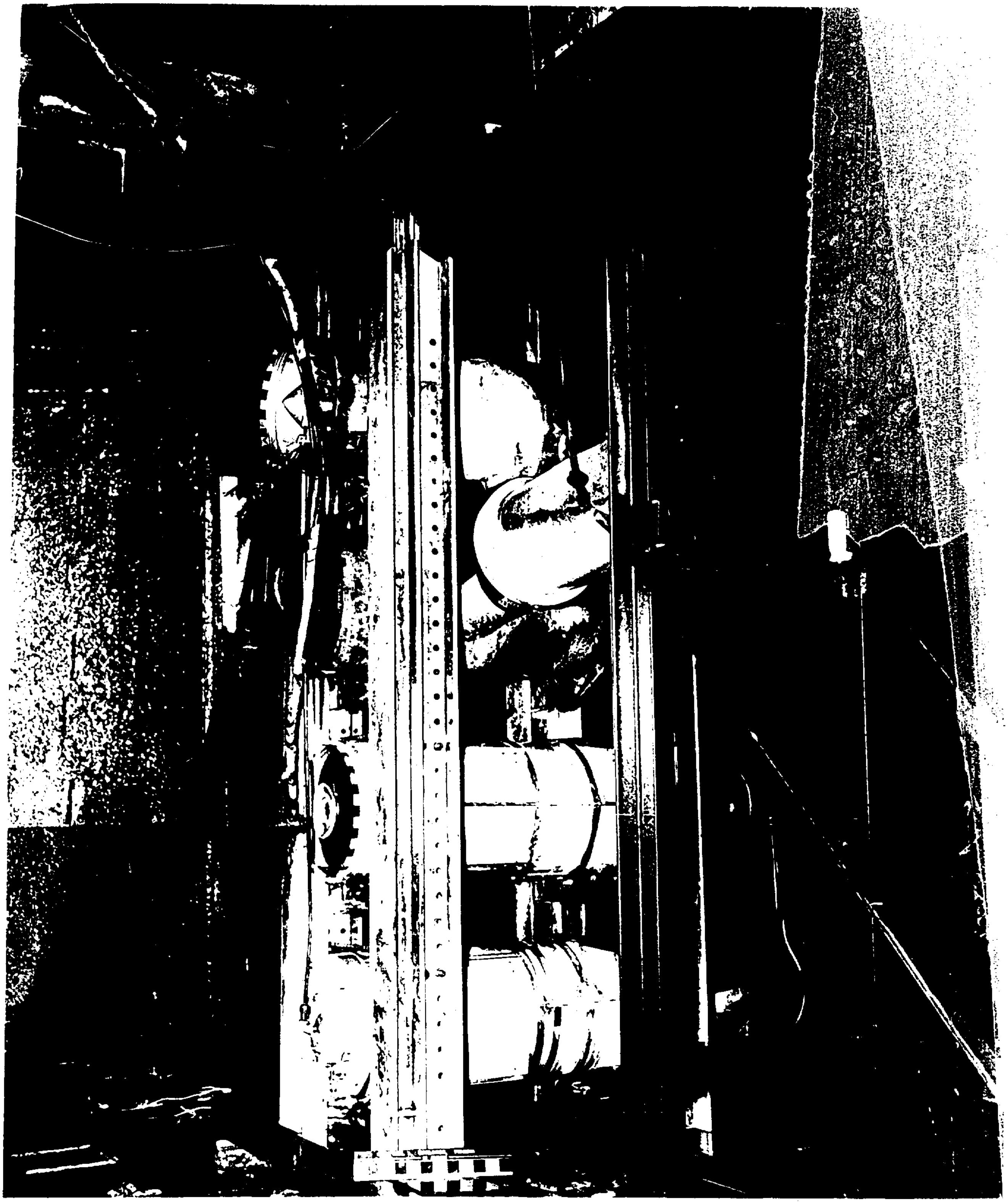
Test B-3-a. View of arrangement after test. Note paint removed from the passive units by the IRFNA.



PHD-89884-6-62 Figure 29 13 June 196?

Test B-3-b. View of arrangement after test.

UNCLASSIFIED



PHD-89885-6-62 Figure 30 29 June 1962

Test B-3-b-1. View of arrangement after test.

UNCLASSIFIED

TABLE 2 TEST RESULTS

(Note: Zero time is close of firing key for separating explosive bolt or operating solenoid which initiates spillage unless otherwise noted.)

Test A-1-a

Magazine Temperatures (two locations)

| | Ambient | Time of First Rise | |
|---|---|---|---|
| Above the active unit | 77°F | 1.5 sec. | 2500°F at 7 sec. |
| Above the passive units | 77°F | 2.6 sec. | 850°F at 10.0 sec. |

Active Liquid-Propellant Engine Temperatures

| | First Rise | At 16.5 seconds | Maximum |
|---|---|---|---|
| Position 2, 7 | No rise was noted. | | |
| Position 3 | 4.0 sec. | 209°F | 300°F at 35 sec. |
| Position 4 | 4.0 sec. | 199°F | 330°F at 35 sec. |
| Position 5 | 4.6 sec. | 177°F | 180°F at 17 sec. |

Passive Liquid-Propellant Engine Temperatures

| | | | |
|---|---|---|---|
| Position 2, 5 | No rise was noted. | | |
| Position 3 | 15.0 sec. | 79°F | 133°F at 50 sec. |
| Position 4 | 17.0 sec. | 77°F | 134°F at 50 sec. |
| Position 7 | 45 sec. | 77°F | 90°F at 140 sec. |

Passive Solid-Propellant Motor Temperatures

| | | | |
|---|---|---|---|
| Position 2, 7 | No rise was noted. | | |
| Position 3 | 5.0 sec. | 80°F | 100°F at 90 sec. |

Warhead

| | |
|---|---|
| Positions 1, 2, 3, 4 and 5 | No rise was noted. |

TABLE 2 (Continued)

Test A-1-b

Magazine Temperature (above the active unit)

| Ambient | Time of First Rise | Maximum |
|---|---|---|
| 64°F | 1.5 sec. | 2400°F at 5 sec. |

Passive Units Temperature

All instrumentation on the passive units was destroyed.

Active Engine Thrust

| Maximum Thrust | Time of Decline to Zero |
|---|---|
| 4100 lbs at 2.9 sec. | 5.0 sec. |

Time of Vent Opening

3.180 sec.

Test A-1-c

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline to Zero |
|---|---|---|
| 0.735 sec. | 7 psi at 7.40 sec. | 20.0 sec. |

Magazine Temperature (above the active unit)

| Ambient | Time of First Rise | Maximum |
|---|---|---|
| 59°F | 1.0 sec. | 1830°F at 11.5 sec. |

TABLE 2 (Continued)

Initiator Temperature in Empty Engine

| | Time of First Rise | At 16 sec. | Maximum |
|---|---|---|---|
| Position 6 | 8 sec. | 67°F | 116°F at 240 sec. |

Test A-2-a

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline of Zero |
|---|---|---|
| 3.30 sec. | 9.1 psi at 10.6 sec. | 30.0 sec. |

Magazine Temperatures (two locations)

| | Ambient | Time of First Rise | Maximum |
|---|---|---|---|
| Above the active unit | 91°F | 3.75 sec. | 2500°F at 8.8 sec. |
| Above the passive units | 91°F | 4.55 sec. | 1900°F at 11.8 sec. |

Active Solid-Propellant Engine Temperatures

| | Time of First Rise | At 18.75 sec. | Maximum |
|---|---|---|---|
| Position 1 | 25 sec. | 91°F | 109°F at 220 sec. |
| Position 3 | 5.0 sec. | 156°F | 199°F at 220 sec. |
| Position 4 | 5.0 sec. | 126°F | 159°F at 220 sec. |
| Position 5 | 8.0 sec. | 119°F | 285°F at 40.0 sec. |
| Position 7 | 9.0 sec. | 91°F | 100°F at 220 sec. |

Passive Solid-Propellant Motor

| | | | |
|---|---|---|---|
| Position 1 | 30 sec. | 91°F | 102°F at 150 sec. |
| Position 3 | 12.0 sec. | 103°F | 144°F at 150 sec. |
| Position 4 | 12.0 sec. | 91°F | 136°F at 150 sec. |
| Position 5 | 4.0 sec. | 171°F | 175°F at 25 sec. |
| Position 7 | No rise was noted. | | |

TABLE 2 (Continued)

Passive Liquid-Propellant Engine

| | Time of First Rise | At 18.75 sec. | Maximum |
|---|---|---|---|
| Position 1, 7 | No rise was noted. | | |
| Position 3 | 12.0 sec. | 110°F | 123°F at 30 sec. |
| Position 4 | 12.0 sec. | 245°F | 245°F at 20 sec. |
| Position 5 | 10.0 sec. | 99°F | 119°F at 21.6 sec. |

Warhead Temperatures

Positions 1, 2, No rise was noted.
3, 4 and 5

Test A-2-b

(Note: The active solid-propellant motor was electrically ignited 3.6 seconds after zero time.)

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline to Zero |
|---|---|---|
| 0.210 sec. | 15.3 psi at 3.76 sec. | 7.6 sec. |

Magazine Temperature (two locations)

| | Ambient | Time of First Rise | Maximum |
|---|---|---|---|
| Above the active unit | 80°F | 1.240 sec. | 2130°F at 4.2 sec. |
| Above the passive unit | 80°F | 1.5 sec. | 1880°F at 5.9 sec. |

Passive Solid-Propellant Motor Temperatures

| | Time of First Rise | At 16.24 sec. | Maximum |
|---|---|---|---|
| Position 1 | 120 sec. | 80°F | 106°F at 600 sec. |
| Position 3 | 6.6 sec. | 80°F | 159°F at 60 sec. |
| Position 4 | 6.6 sec. | 122°F | 152°F at 480 sec. |
| Position 5 | 6.6 sec. | 104°F | 111°F at 480 sec. |
| Position 7 | 240 sec. | 80°F | 89°F at 480 sec. |

TABLE 2 (Continued)

Passive Liquid-Propellant Engine Temperatures

| | Time of First Rise | At 16.24 sec. | Maximum |
|---|---|---|---|
| Position 1, 7 | No rise was noted. | | |
| Position 3 | 5.1 sec. | 169°F | 170°F at 14 sec. |
| Position 4 | 4.2 sec. | 156°F | 156°F at 18 sec. |
| Position 5 | 3.75 sec. | 109°F | 204°F at 21 sec. |

Warhead Temperatures

| | | | |
|---|---|---|---|
| Position 1 | 120 sec. | 80°F | 89°F at 420 sec. |
| Position 2 | 420 sec. | 80°F | 83°F at 480 sec. |
| Position 3 | 360 sec. | 80°F | 84°F at 480 sec. |
| Position 4 | 360 sec. | 80°F | 85°F at 480 sec. |
| Position 5 | 150 sec. | 80°F | 96°F at 480 sec. |

Time of Vent Opening

3.725 sec.

Test B-1-a (Mod)

(Note: Zero time is close of firing key for electrical ignition.)

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline to Zero |
|---|---|---|
| 0.060 sec. | 17.0 psi at 0.452 sec. | 2.0 sec. |

Magazine Temperature

| Ambient | Time of First Rise | Maximum |
|---|---|---|
| 73°F | 0.110 sec. | 2087°F at 2.430 sec. |

TABLE 2 (Continued)

Passive Liquid-Propellant Engine Temperatures

| | Time of First Rise | At 15 sec. | Maximum |
|---|---|---|---|
| Position 1 | No rise was noted. | | |
| Position 3 | 4.0 sec. | 120°F | 121°F at 15 sec. |
| Position 4 | 4.0 sec. | 122°F | 127°F at 10 sec. |
| Position 7 | 0.3 sec. | 73°F | 83°F at .600 sec. |

Passive Solid-Propellant Motor Temperatures

| | Time of First Rise | At 15 sec. | Maximum |
|---|---|---|---|
| Position 1 | 0.5 sec. | 73°F | 84°F at 360 sec. |
| Position 6 | 0.42 sec. | 73°F | 83°F at 0.5 sec. |

Time of Vent Opening

0.452 sec.

Test B-2-a (Mod)

(Note: Zero time is close of firing key for electrical ignition.)

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline to Zero |
|---|---|---|
| 0.045 sec. | 21.3 psi at 0.600 sec. | 3.0 sec. |

Magazine Temperature

| Ambient | Time of First Rise | Maximum |
|---|---|---|
| 70°F | 0.09 sec. | 2484°F at 0.981 sec. |

TABLE 2 (Continued)

Passive Solid-Propellant Motor Temperatures

| | Time of First Rise | At 17.28 sec. | Maximum |
|---|---|---|---|
| Position 1 | 4 min. | 79°F | 115°F at 25 min. 52 sec. |
| Position 3 | 6.0 sec. | 164°F | 1662°F at 2 min. 56 sec. |
| Position 4 | 6.0 sec. | 184°F | 1650°F at 1 min. 25 sec. |
| Position 5 | 8.0 sec. | 79°F | 1487°F at 2 min. |
| Position 7 | 8.0 sec. | 79°F | 93°F at 25 min. 52 sec. |

Warhead Temperatures

| | Time of First Rise | At 17.28 sec. | Maximum |
|---|---|---|---|
| Position 1 | 90 sec. | 79°F | 127°F at 20 min. |
| Position 2 | 90 sec. | 79°F | 103°F at 25 min. |
| Position 3 | 90 sec. | 79°F | 140°F at 10 min. |
| Position 4 | 90 sec. | 79°F | 134°F at 22 min. |
| Position 5 | 90 sec. | 79°F | 190°F at 22 min. |

Test B-3-b

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline to Zero |
|---|---|---|
| 1.1 sec. | 0.8 psi at 8 sec. | 50 sec. |

Magazine Temperature

| Ambient | Time of First Rise | Maximum |
|---|---|---|
| 70°F | 1.2 sec. | 2183°F at 8 sec. |

Passive Liquid-Propellant Engine Temperatures

| | Time of First Rise | At 17.2 sec. | Maximum |
|---|---|---|---|
| Position 1 | 10 min. | 70°F | 77°F at 13 min. 48 sec. |
| Position 3 | 3 sec. | 1096°F | 1572°F at 24 sec. |
| Position 4 | 3 sec. | 986°F | 1050°F at 10 sec. |
| Position 5 | 3 min. | 70°F | 94°F at 13 min. 30 sec. |
| Position 7 | 10 min. | 70°F | 75°F at 13 min. 48 sec. |

TABLE 2 (Continued)

Passive Solid-Propellant Motor Temperatures

| | Time of First Rise | At 17.2 sec. | Maximum |
|---|---|---|---|
| Position 1 | 1 min. | 70°F | 85°F at 10 min. |
| Position 3 | 2 sec. | 787°F | 1649°F at 28 sec. |
| Position 4 | 2 sec. | 1050°F | 1675°F at 15 sec. |
| Position 5 | 4 sec. | 433°F | 1423°F at 1 min. |
| Position 7 | 1 min. | 70°F | 75°F at 4 min. |

Warhead Temperatures

| | | | |
|---|---|---|---|
| Position 1 | 40 sec. | 70°F | 99°F at 11 min. |
| Position 2 | 40 sec. | 70°F | 83°F at 13 min. 30 sec. |
| Position 3 | 40 sec. | 70°F | 132°F at 5 min. |
| Position 4 | 40 sec. | 70°F | 109°F at 13 min. 30 sec. |
| Position 5 | 40 sec. | 70°F | 109°F at 11 min. |

Test B-3-b-1

Magazine Pressure

| Time of First Rise | Maximum | Time of Decline to Zero |
|---|---|---|
| 3 sec. | 0.6 psi at 10 sec. | 80 sec. |

Magazine Temperature

| Ambient | Time of First Rise | Maximum |
|---|---|---|
| 75°F | 1 sec. | 2045°F at 14.5 sec. |

TABLE 2 (Continued)

Passive Liquid-Propellant Engine Temperatures

| | Time of First Rise | At 16 sec. | Maximum |
|---|---|---|---|
| Position 1 | 20 sec. | 75°F | 91°F at 2 min. |
| Position 2 | 18 sec. | 75°F | 87°F at 2 min. |
| Position 3 | 5 sec. | 157°F | 375°F at 1 min. 30 sec. |
| Position 4 | 5 sec. | 144°F | 764°F at 1 min. 21 sec. |
| Position 5 | 5 sec. | 76°F | 109°F at 6 min. |
| Position 8 | 7 sec. | 77°F | 114°F at 37 sec. |
| Position 9 | 7 sec. | 77°F | 146°F at 37 sec. |

Passive Solid-Propellant Motor Temperatures

| | | | |
|---|---|---|---|
| Position 1 | 3 sec. | 83°F | 107°F at 2 min. 20 sec. |
| Position 2 | 3 sec. | 84°F | 104°F at 2 min. 20 sec. |
| Position 3 | 3 sec. | 89°F | 199°F at 1 min. 40 sec. |
| Position 4 | 3 sec. | 96°F | 185°F at 1 min. 40 sec. |
| Position 5 | 20 sec. | 75°F | 487°F at 2 min. 20 sec. |
| Position 5 (Pyrolock) | 20 sec. | 79°F | 176°F at 2 min. 20 sec. |
| Position 6 | 30 sec. | 75°F | 155°F at 2 min. |

Warhead Temperatures

| | | | |
|---|---|---|---|
| Position 1 | 42 sec. | 75°F | 92°F at 6 min. |
| Position 2 | 42 sec. | 75°F | 79°F at 6 min. |
| Position 3 | 38 sec. | 75°F | 104°F at 6 min. |
| Position 4 | 42 sec. | 75°F | 100°F at 6 min. |
| Position 5 | 42 sec. | 75°F | 105°F at 6 min. |

APPENDIX E

## DISTRIBUTION

| | |
|---|---|
| Bureau of Naval Weapons | |
| DLI-31 | 2 |
| RMMP-43 | 2 |
| RMMP-3 | 1 |
| RSWI | 2 |
| RMMP-42 | 1 |
| RM-15 | 1 |
| RMMO | 1 |
| RMGA | 1 |
| C-13 | 1 |
| RMWS | 1 |
| RMMP-24 | 1 |
| RM-375 | 1 |
| Commander<br>Armed Services Technical Information Agency<br>Arlington Hall Station<br>Arlington 12, Virginia<br>Attn: TIPDR | 10 |
| Commanding General<br>Aberdeen Proving Ground<br>Aberdeen, Maryland<br>Attn: Technical Information Section<br>Development and Proof Services | 2 |
| Commander, Operational Development Force<br>U. S. Atlantic Fleet, U. S. Naval Base<br>Norfolk 11, Virginia | 1 |
| Chief, Bureau of Ships | |
| Code 603 | 4 |
| Technical Library | 1 |
| Reaction Motors Division<br>Thiokol Chemical Corporation<br>Denville, New Jersey<br>Attn: Mr. Mairer | 1 |

DISTRIBUTION (Continued)

| | |
|---|---|
| Vitro Laboratories<br>Silver Spring Laboratory<br>14000 Georgia Avenue<br>Silver Spring, Maryland | 1 |
| Commanding Officer<br>Naval Air Engineering Facility (SI)<br>Philadelphia Naval Base 12, Pennsylvania<br>Attn: Code SE-245 | 1 |
| Naval Missile Center<br>Pt. Mugu, California<br>Attn: Technical Library | 2 |
| NOTS<br>China Lake, California<br>Attn: Code 45 | 2 |
| Technical Library | 1 |
| R. F. Busic<br>R and D Department<br>Code RE3A<br>Naval Propellant Plant<br>Indian Head, Maryland | 1 |
| Local: | |
| WWE | 3 |
| WDE | 1 |
| WWT | 1 |
| WX | 1 |
| W | 1 |
| WW | 1 |
| ACL | 5 |
| File | 1 |

## BIBLIOGRAPHIC INFORMATION

| DESCRIPTOR | CODE | DESCRIPTOR | CODE |
|---|---|---|---|
| SOURCE<br>NAVAL WEAPONS LABORATORY | NPGA | SECURITY CLASSIFICATION AND CODE COUNT<br>CONFIDENTIAL | 0Ø17 |
| REPORT NUMBER<br>1832 | 1832 | CIRCULATION LIMITATION | |
| REPORT DATE<br>16 NOVEMBER 1962 | 1162 | CIRCULATION LIMITATION OR BIBLIOGRAPHIC | |
| | | BIBLIOGRAPHIC *(Suppl., Vol., etc.)* | |

## SUBJECT ANALYSIS OF REPORT

| DESCRIPTOR | CODE | DESCRIPTOR | CODE | DESCRIPTOR | CODE |
|---|---|---|---|---|---|
| GUIDED | GUIE | CHAIN | CHAI | | |
| MISSILES | MISL | IGNITION | IGNT | | |
| AIRCRAFT | AIRC | INITIATOR | INIT | | |
| LAUNCHED | LAUC | | | | |
| MAGAZINES | MAGA | | | | |
| STORAGE | STOR | | | | |
| HAZARDS | HAZA | | | | |
| COMPATIBILITY | CMPL | | | | |
| LIQUID | LIQU | | | | |
| SOLID | SOLI | | | | |
| PROPELLANT | FUEL | | | | |
| BULLPUP | BULL | | | | |
| SHIPBOARD | SHIB | | | | |
| ROCKET MOTORS | ROCK | | | | |

Naval Weapons Laboratory, Dahlgren, Virginia.
(NWL Report No. 1832)
INVESTIGATION OF STOWAGE HAZARDS IN AIR LAUNCHED MISSILE MAGAZINES: THE COMPATIBILITY OF PREPACKAGED LIQUID- AND SOLID-PROPELLANT BULLPUP MISSILES IN A COMMON SHIPBOARD MAGAZINE (U), by R. H. Quillin and E. M. Parry. 16 Nov 1962. 31 p., 30 figs.
CONFIDENTIAL

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2. Guided missiles - Storage
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II. Parry, E. M.
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TASK: RM3754-001/210-1/W024-00-004

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